Medical History

Missed injuries of the spinal cord

G RAVICHANDRAN, J R SILVER

Abstract

Damage to the spinal cord had not been recognised initially in 15 patients out of a consecutive series of 353 admitted over a decade to the National Spinal Injuries Centre with paralysis due to trauma to the cord. In some patients the missed diagnosis led to mismanagement and a greater neurological deficit. Missed injuries of the spinal cord are seen in patients with multiple injuries and head injuries and in those without any paralysis. Various radiological errors contribute to the failure to recognise the vertebral injury. In addition to causing severe disability to the victim these missed and mismanaged injuries of the spinal cord cost the National Health Service large sums in compensation. A careful evaluation of the history of each accident, with greater awareness of the potential of certain types of accidents to cause spinal cord injury, should reduce the incidence of missed injuries of the spinal cord.

Trauma to the vertebral column injuring the spinal cord and causing paralysis is one of the worst disasters that can ever befall an individual. From 13 to 27 per million residents of the United Kingdom are likely to suffer from serious paralysis each year as a result of injury of the spinal cord.¹⁻³ If we include cases of sudden death after accident in which necropsy shows spinal cord injury the incidence is about 50 per million a year.⁴ Nearly 40% of all cases result from motor car or motorcycle accidents.²⁻⁸

The morbidity associated with injury of the spinal cord⁹ can be reduced by prompt recognition of the injury to the cord,

preferably at the site of the accident. Increased awareness of such injuries by ambulance personnel has led to improved handling and transport of the victim. A few patients with injury of the spinal cord, however, remain undiagnosed even after arrival at accident and emergency departments. Ohry¹⁰ reports two cases of missed fractures from traumatic injury of the spinal cord from Israel in a series of patients in whom the cause of the paralysis remained uncertain for several years. The present study was undertaken to determine the various causes that contribute to the failure to recognise injury of the spinal cord and their consequences in the hope of reducing such instances in the future.

Materials and methods

Medical records were reviewed of all patients admitted to one of the acute male wards in the National Spinal Injuries Centre over the decade ending in March 1981. Relevant radiographs and medicolegal documents were also studied. Twenty patients were excluded from this study because their paralysis was not related to trauma. Of 353 patients included for this study, the injury of the spinal cord was not recognised initially in 15 patients.

Results

Eleven of the 15 patients with missed injuries had injuries to the cervical spine. The remaining four were paraplegics as a result of injury to the dorsal spine. Table I shows the extent of the delay in recognising the injury of the spinal cord in the 15 patients, and how the correct diagnosis was made in each case. The final outcome is shown in table II.

In most cases the initial diagnosis was either head injury or neck injury; the extent of the initial neurological deficit was estimated from the records of the referring hospitals. In most cases the records gave limited details of the neurological examination. At least 10 patients (two paraplegics, eight tetraplegics) with missed injuries of the spinal cord deteriorated neurologically as a result of the initial management.

National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, Bucks HP21 8AL

G RAVICHANDRAN, BSC, FRCS, senior registrar in spinal injuries
J R SILVER, FRCP, consultant in spinal injuries

Table III shows the various causes that contributed to the failure in recognising the injury of the spinal cord in each case.

The 15 patients reported here were from a consecutive series of 353 patients with acute traumatic injury of the spinal cord admitted to one male ward under the care of one consultant in spinal injuries. This gives an overall incidence of 4.3% for missed injuries of the spinal cord. Failure to recognise the injury of the spinal cord was nearly three times more common among tetraplegic patients than among the paraplegics. A further study was undertaken to establish the prevalence of this condition among patients in other wards of this unit. Towards

TABLE IV—Increase in the incidence of missed injuries of the spinal cord

Year	1971	72	73	74	75	76	77	78	79	80
No of missed injuries of the spinal cord	1	1	1	2	1	0	0	3	2	3

the end of the decade studied, 64 patients (41 men, 23 women) with acute traumatic injury of the spinal cord were in the three acute wards of this centre. In five of the 64 patients (four men, one woman; two paraplegics, three tetraplegics) the injury of the spinal cord was missed initially. There appears to have been a notable increase in the incidence of missed injuries of the spinal cord recently (table IV).

Discussion

Cord damage may be missed on clinical examination as a result of six possible contributory factors—namely: the circumstances surrounding the accident; the absence of any serious neurological deficit initially; head injury; multiple injuries; radiographic or radiodiagnostic errors; and failure to appreciate the mechanism of injury.

(1) Ambience. A history of being chased by the police on a suspected charge of theft (two cases), a strong smell of alcohol on the breath (four cases), and a previous diagnosis of a progressive neurological disorder appear to have influenced the medical officer's judgment of the neurological state of the patient. We know of at least three instances (including two cases not included in this series) in which patients with paralysis were sent home. One of these had a progressive neurological disorder and another ankylosing spondylitis, and the third was thought to be hysterical. Two of these were not correctly diagnosed even by the general practitioners, who made home visits at the insistence of the relatives.

(2) Minimal or no neurological deficit at the time of first admission was associated with failure to diagnose injury of the spinal cord in four patients. They all had injuries to the cervical spine and became worse as a result of the initial management. Severe pain in the neck and symptoms of root irritation were the presenting complaints in each case. At least two of the patients had priapism, and all of them developed retention of urine.

In the accident and emergency departments every conscious patient should be examined for paralysis or paradoxical respiration and any symptoms of root irritation should be adequately assessed. A clinical sign of varying degree of torticollis without sternomastoid spasm that has followed a neck injury should always alert the doctor to the possibility of a major apophyseal joint injury.¹¹ A more detailed neurological assessment, with appreciation of the mechanism of the injury, could have prevented the major neurological deficits that followed the initial management in these patients.

(3) Six of the 15 patients had severe head injury on initial admission and could not give details of the accident (table III). Two others had transient head injury not directly contributing to the failure to diagnose injury of the spinal cord. Spinal cord paralysis due to a spinal cord lesion may be missed in deeply unconscious patients, but routine radiographs of the entire spine in all cases of serious head injury with detailed and repeated neurological assessment could have prevented at least some of the morbidity suffered by the patients in the group. In two of the patients, even though paralysis originating from the spinal cord was suspected on first medical examination, the absence of a radiologically demonstrable fracture in the spine led to a change in the diagnosis to head injury. Both these patients became worse as a result. Radiological signs are only a guide, and their absence should not mean that clinical signs are ignored.

(4) In addition to injury of the spinal cord multiple skeletal and soft-tissue injuries were noted in five patients (table III). These included multiple rib fractures with haemothoraces and

TABLE I—Extent of delay in recognising injury of the spinal cord

Case No	Time lapse before cord injury diagnosed	How correct diagnosis made
1	10 days	Subsequent neurological opinion
2	1 day	Repeat radiograph
3	1 day	Re-examination
4	5 days	Subsequent neurosurgical opinion
5	3 weeks	Deterioration of neurological state
6	12 hours	Deterioration of neurological state
7	2 days	Second neurosurgical opinion
8	1 day	From overpenetrated radiograph of chest
9	3 days	Subsequent neurological examination
10	3 days	Second neurosurgical opinion
11	12 hours	Subsequent neurological examination and radiographs
12	3 days	Subsequent neurological opinion
13	6 days	Deterioration of neurological state
14	1 day	Deterioration of neurological state
15	2 days	Clinical examination by general practitioner

TABLE II—Final outcome of failure to recognise injury of spinal cord initially

Case No	Primary diagnosis	Initial* neurological state due to SCI	Neurological state when correct diagnosis made	Influence of initial management on cord function	Neurological state subsequent to management at spinal injuries centre
1	Cardiac arrest	Tetraparesis	Tetraplegia	Adverse	Improved
2	Paraparesis	Paraparesis	Paraplegia	Adverse	Improved
3	Respiratory distress	Tetraplegia	Paraplegia	Unknown	Unchanged
4	Head injury	Unknown	Tetraplegia	Adverse	Improved
5	Drunk	Hemiparesis	Tetraparesis	Adverse	Improved
6	Neck injury	Tetraparesis	Tetraplegia	Adverse	Improved
7	Head injury	Tetraparesis	Tetraplegia	Adverse	Improved
8	Head injury, multiple fractures	Unknown	Paraplegia	Unknown	Unchanged
9	Head injury, multiple fractures	Paraplegia	Paraplegia	Unknown	Unchanged
10	Drunk head injury	Hemiplegia	Tetraplegia	Adverse	Improved
11	Drunk, drowning	Tetraparesis	Tetraplegia	Unknown	Unchanged
12	Haemothorax, head injury	Paraparesis	Paraplegia	Adverse	Unchanged
13	Neck injury	C7 root damage	Tetraplegia	Adverse	Improved
14	Pain in neck	Retention paresthesia	Tetraparesis	Adverse	Improved
15	Neck injury	?Tetraplegia	Tetraplegia	Adverse	Unchanged

*See text.

SCI = Injury of spinal cord.

TABLE III—Causes of missing the injury of the spinal cord

Case No	Radiological* causes	Head injury	Absent/minimal paralysis	multiple injuries	Other causes
1	1, 2, 4, 5	?	—	?	—
2	4, 5	—	—	—	—
3	1, 2, 4, 5	—	—	+	—
4	4	+	—	+	—
5	1, 74, 75	—	+	—	Drunk
6	4, 5	—	+	—	—
7	1, 2, 4, 5	+	—	—	In a stolen car chased by police
8	2	Minor	?	+	Police chasing motor cyclist
9	4	+	?	+	—
10	1, 2, 5, 6	+	—	—	Drunk
11	3	+	—	—	Drunk and drowning
12	1, 4, 5	+	—	+	—
13	1, 2, 4, 5, 76	—	+	—	Cervical spondylosis
14	1, 2, 4, 5	—	+	—	Smell of alcohol on breath
15	2, 4	—	—	—	Progressive demyelination

*Radiological causes: 1 = poor quality radiograph, 2 = inadequate radiograph, 3 = failure to x-ray the part, 4 = failure to interpret, 5 = failure to understand the mechanism of injury, 6 = injuries difficult to show radiologically.

pneumothoraces (four cases), major fractures of extremities (three cases), fractured skull (one case), and profound shock (five cases). In addition to these injuries one patient developed acute gastric dilatation and severe haematemesis one week after the accident.

In these severely ill patients the medical teams made dedicated efforts to resuscitate; and the injury of the spinal cord was overlooked initially. The pressures on the medical teams during any major resuscitation are well known.¹² It is somewhat disconcerting to note, however, that in at least four cases the paralysis was first reported by the relatives of the victim before the medical team appreciated it.

(5) Isolated reports on the difficulties of recognising certain injuries of the cervical spine have appeared in the past. In our study missed injuries of the spine were associated with fractures of the cervical spine in 11 patients and the dorsal spine in four. In at least eight of these the poor quality of the radiographs made proper recognition of the bony architecture extremely difficult. The lateral projections of most patients with tetraplegia failed to show details of the cervicodorsal junction.

The anteroposterior radiographs of the cervical spine usually show the bony abnormalities after injury. Fractures of the body, isolated malalignment of the spinous process in the sagittal plane, undue widening or crowding of the spinous process, and, in certain instances, fractures of the neural arch or lateral mass can be recognised by a careful scrutiny of the anteroposterior radiographs. When any one or more radiological abnormalities are suspected further views to confirm the extent of the bony injury are imperative. These include sustained and carefully supervised pulled lateral views,¹³⁻¹⁶ supine oblique views, tomograms, and swimmer's views. Pulling the arms to obtain a better lateral view of the cervicodorsal junction should not be delegated to the radiographer. Once a bony injury is suspected from routine radiographs, the patient's neck should be immobilised with sandbags on either side of the head and all further radiographic procedures must be supervised by senior medical officers of the relevant disciplines. This should minimise further injury to the cord during radiography.

When studying lateral radiographs of the cervical spines of these patients the doctor must judge the alignments of: (a) the anterior margins of the body of the vertebrae, (b) the posterior margins of the body of the vertebrae, (c) the apophyseal joints, and (d) the laminar line (an interrupted line formed by joining the site of confluence of the laminae of each vertebra).¹⁷

In elderly patients with cervical spondylosis (cases 10 and 13) radiographic demonstrations of the fractures may be difficult. Any undue widening of a disc space, separation of osteophytes, avulsion of the anteroinferior margins of the body, or fracture of the spinous process should alert the medical officer to the possibility of a major ligamentous disruption. Rarely, unexplained widening of the prevertebral soft tissue may be the only radiological sign of an injury to the cervical spine.¹⁸ There are instances where no bony injury may be demonstrable even after the most meticulous radiological assessment.¹⁹ The accident and emergency officers should be guided by the clinical signs and symptoms in these cases.

(6) Most injuries were the result of considerable violence. Studies²⁰ have shown that the human body can withstand a deceleration of 300 metres per second per second (30 G) without injury. If a vehicle travelling at a speed of 50 km/h (31 mph) comes to rest within 5 cm after a collision the deceleration of a driver weighing about 70 kg (154 lb) will be about 1900 m/s/s (195 G, 136 kN). This is beyond the impact tolerance of the human body, and severe and uncontrolled deformation of various unprotected parts of the body results (cases 1, 3, 4, 7, 15). The parts of the body chiefly at risk in motorcycle accidents are the head and legs.²¹ Eighty per cent of all fatalities are the result of head and neck injuries in motorcycle accidents.²² Diving into shallow water, when the head hits the bottom, leads to severe deceleration that not only produces signs of head injury but also fractures of the cervical spine (case 11).

Failure to appreciate the forces concerned in each accident contributed to inadequate investigation and examination of the victims and led to erroneous conclusions. A considerable proportion of drivers and occupants in automobile accidents suffer injuries of the cervical spine. The victims of car, motorcycle, or diving accidents who give a history of varying degrees of loss of consciousness should perhaps be admitted and observed.

When paralysis follows the initial management, or when the paresis observed by the victim or the relatives is ignored by the medical staff, litigation against the hospital is likely. In at least five instances the failure to recognise the vertebral injury and subsequent management of the patient have contributed to rapid deterioration of the neurological state. None of them regained all the neurological functions that they had had on admission. In one of these patients, even though the radiographer and the medical officer of the accident and emergency department recognised the bony injury and alerted a more senior doctor, no treatment was started because the patient had no major neurological deficit (figure). His records show a well-

Lateral cervical spine radiograph of a man admitted after a trampoline accident without any apparent neurological deficit. The inferior facet of C5 (square) is not articulating with superior facet of C6 (triangle), which has dislocated posteriorly. The posteroinferior angle of body of C5 (arrow) is not in alignment with posterosuperior angle of C6. This patient developed tetraplegia in hospital with incomplete neurological recovery even after reduction of dislocation.

documented progressive deterioration of the spinal cord functions until the next morning, when the dislocated spine was reduced. In this case claims for damages were settled by the appropriate area health authority for over £100 000.

Missed injuries of the spinal cord seldom occur as a result of an isolated cause (table III). The pitfalls in diagnosing injury of the spinal cord have been delineated. If failures to diagnose the injury are to be avoided a careful evaluation of the history is essential. All requests for radiographs should be made after due consideration of the expected forces produced by each accident. Anyone complaining of severe pain in the region of his spine after an injury and who has even minor signs and symptoms of either root irritation or cord damage should be treated as potentially having an injury of the spinal cord, irrespective of the radiological findings. The patient should be immobilised in bed and carefully observed for any deterioration in neurological state. At the first sign of any deterioration urgent help from more senior members of the medical team should be summoned. We believe that these measures will greatly reduce the incidence of missed injuries of the spinal cord.

References

- ¹ Fine PR, Kuhlemeier KV, De Vivo MJ, Stover SL. Spinal cord injury: an epidemiological perspective. *Paraplegia* 1980;**17**:237-50.
- ² Castanier MM, Garard R, Berard E, Deider C, Bourret J. Epidemiology of spinal cord injury in Rhodé-Alpes region, France 1970-75. *Paraplegia* 1979;**16**:76-87.
- ³ Kurtzke JF. Epidemiology of spinal cord injury. *Exp Neurol* 1975;**48**:163-236.
- ⁴ Krans JF, Franti CE, Riggins RS, Richards D, Borman NO. Incidence of traumatic spinal cord lesion. *J Chronic Dis* 1975;**28**:471-92.
- ⁵ Krans JF. A comparison of recent studies on the extent of the head and spinal cord injury problem in the United States. *J Neurosurg* 1980;**53**:S35-S43.
- ⁶ Shrosbree RD. Spinal cord injury as a result of motor cycle accidents. *Paraplegia* 1979;**16**:102-12.
- ⁷ Silver JR, Morris WR, Orfinowski JS. Associated injuries in patients with spinal injury. *Injury* 1980;**12**:219-24.
- ⁸ Huelke DF, O'Day J, Mendelsohn RA. Cervical injuries suffered in automobile crashes. *J Neurosurg* 1981;**54**:316-22.
- ⁹ Bedbrook GM. Spinal cord injury with tetraplegia and paraplegia. *J Bone Joint Surg (Br)* 1979;**61**:267-84.
- ¹⁰ Ohry A, Brooks ME, Rozin R. Misdiagnosis of spinal cord injuries—the physiatrist's point of view. *Paraplegia* 1980;**18**:15-20.
- ¹¹ Ravichandran G. Traumatic single facet subluxation without neurological damage of the cervical spine—a new clinical sign. *Archives of Orthopaedic and Traumatic Surgery* 1978;**92**:221-4.
- ¹² Morpurgo CV. *The treatment of patients with multiple injuries associated with damage to the spinal cord. Recent progress in anaesthesiology and resuscitation.* Amsterdam: Excerpta Medica, 1975:471-5.
- ¹³ Scher AT. Cervical spine injuries without evidence of fracture or dislocation. *S Afr Med J* 1976;**50**:962-5.
- ¹⁴ Scher AT. Unilateral locked facet in cervical spine injuries. *AJR* 1977;**129**:45-8.
- ¹⁵ Scher AT. Unrecognised fractures and dislocations of the cervical spine. *Paraplegia* 1981;**19**:25-30.
- ¹⁶ Penning L. Diagnostic clues by x-rays—injuries of the lower cervical spine. *Acta Neurochir (Wien)* 1970;**22**:234-44.
- ¹⁷ Wholey MH, Bruwer AJ, Baker HL. The lateral roentgenogram of the neck; with comments on atlanto odontoid basin relationship. *Radiology* 1958;**71**:350-6.
- ¹⁸ Whalen JP, Woodruff CL. The cervical prevertebral fat stripe. A new aid in evaluating the cervical prevertebral soft tissue space. *AJR* 1970;**109**:445-51.
- ¹⁹ Taylor AR, Blackwood W. Paraplegia in cervical injuries with normal radiographic appearance. *J Bone Joint Surg* 1948;**30B**:245-8.
- ²⁰ Snyder RG. Quoted by Cullen SA in: Mason JK, ed. *The pathology of violent injury.* London: Edward Arnold, 1978.
- ²¹ Bothwell PW. The problem of motorcycle accidents. *Practitioner* 1962;**188**:475.
- ²² Arnold E. In: Mason JK, ed. *The pathology of violent injury.* London: Edward Arnold, 1978:1-30.

(Accepted 11 December 1982)

Lesson of the Week

Plasmodium falciparum malaria in Nigerians who live in Britain

E WALKER, CATRIONA BRODIE

Plasmodium falciparum malaria affected a Nigerian who was studying in Glasgow and returned home for a short holiday. Malaria caused by *P falciparum* is life-threatening and is not often seen in Glasgow; malaria caused by the more benign *P vivax* is ten times more common.¹ In London, however, such a case would not be unusual.² Many residents of Glasgow have relatives whom they visit in India and Pakistan, where *P vivax* predominates. In London much of the malaria originates in west-central Africa, where *P falciparum* is widespread.

After making a survey among travellers to the Indian sub-continent,³ attitudes to malaria prophylaxis were studied among Nigerians resident in Britain. It emerged that this group does not take the precautions that are normally recommended to travellers overseas.⁴

Case report

A 27-year-old Nigerian student first came to Scotland in 1978. She had had malaria as a child but had had no attacks after the age of 14 years. She returned home for holidays totalling six months over three years, and most recently for three weeks in December 1981. She had taken no antimalarial prophylaxis.

Immunity against malaria declines when constant reinfection stops: re-exposure may then result in serious illness

Five days after returning to Scotland from her latest holiday she developed headache, anorexia, and fever with shivering. These symptoms persisted for four days and she then had hallucinations and repeated vomiting, which caused her admission to hospital. On examination she had a temperature of 39.5°C and was drowsy. The tip of the spleen could be felt and the edge of her liver was palpable and tender. Blood films showed ring trophozoites of *P falciparum* in about 5% of her red blood cells. Her haemoglobin concentration fell below 10 g/dl, but after treatment with chloroquine she recovered steadily.

General attitude to prophylaxis

Fifty-three Nigerians were interviewed in the Nigerian Airways offices in London. All had been resident in Britain for at least two years, and 45 had had malaria before coming to Britain. They were asked about their most recent trip to Nigeria in the past five years: 36 had taken no antimalarial tablets; 16 had taken tablets, but irregularly, or had discontinued them immediately on returning to Britain. Only one person had taken tablets regularly, including the month after return.

The usual reason given for not taking any tablets was that they preferred to treat attacks when they occurred, and this was linked

University Department of Infectious Diseases, Ruchill Hospital, Glasgow G20 9NB

E WALKER, MRCP, MRCP, lecturer in infectious diseases
CATRIONA BRODIE, medical student