Missed and Mismanaged Injuries of the Spinal Cord

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Objective: **The purpose of this study was to determine the incidence of missed and mismanaged injuries of the spinal cord, to identify factors contributing to a failure to recognize such injuries, and to assess the consequences of such failures.**

Methods: **Missed and mismanaged injuries were defined using previously validated statements. All medical records and radiographs of patients with acute traumatic spinal cord injury admitted to the Regional Spinal Cord Injury Unit in Sheffield, United Kingdom, over a period of 10 years from 1989 were evaluated. Patients with no neurologic deficits were excluded from the study.**

Results: **Of the 569 patients, the diagnosis of spinal cord injury was missed in 52 instances (9.1%). The patients were mismanaged in 34 instances, and the treatment offered to 30 was considered negligent. In 26 of 52 (50%), mismanagement resulted in neurologic deterioration. The study identified several factors that contributed to a failure to recognize a spinal cord injury. These include ambience and circumstances surrounding the injury, inadequate neurologic assessment, associated injuries, and radiographic errors.**

Conclusion: **Despite a greater awareness of the potential for spinal injury after road traffic accidents, failure to recognize a spinal cord injury in the acute care setting appears to be increasing. Injuries are seldom missed because of an isolated cause, but rather because of a combination of several factors. Increased vigilance on the part of the primary care physicians and careful documentation may reduce allegations of medical negligence.**

J Trauma. 2002;53:314–320.

Failure to recognize evidence of spinal column injuries because of radiographic or radiodiagnostic errors has been highlighted in several recent articles.[1–9] These reports included patients with and without associated neurologic injuries. The present study was undertaken to identify the causes of failure to recognize vertebral column injuries in patients with coexisting significant neurologic deficit. Our study also addresses the clinical consequences of such failure to recognize spinal cord injury (SCI).

PATIENTS AND METHODS

A retrospective analysis of case records of all 569 SCI patients admitted for comprehensive management to the Regional Spinal Cord Injury Unit in Sheffield during the period April 1989 to April 1999 was conducted. Patients were admitted either directly from the accident and emergency department or after acute management at another referring hospital. Patients who had vertebral column injuries, without neurologic deficits, were excluded from this study.

The extent of primary neurologic deficit was assessed by close scrutiny of the medical and nursing records of all patients where an injury to the spinal column was not recognized initially. From the records, the level of vertebral column injury, the cause of the injury, associated injuries, and the extent of neurologic deficit when it was eventually recognized by the original hospital were retrieved. All available radiographs, including the earliest radiographs from referring hospitals, were reviewed systematically to identify all diagnostic features of bony and soft tissue injury.

For the purposes of this study, the following definitions were used to quantify the extent of "missed" injury to the spinal cord. In some instances, failure to recognize SCI resulted in "mismanagement." The authors felt that a certain proportion of them were managed "negligently." Missed injury was defined as failure to recognize conditions that are likely to cause or contribute to neurologic deterioration. Mismanagement was defined as execution of a "therapeutic" maneuver likely to cause deterioration of the condition. To confirm that the management given in a particular case was negligent, two senior clinicians should be satisfied that there is an established usual and normal practice for the management of the condition suffered by the patient; the person (doctor) must be shown not to have adopted that practice; and the course adopted by that person (doctor) was one that no professional person of ordinary skill would have taken if he or she had acted with ordinary care.[10]

RESULTS

Medical records of 569 patients with neurologic deficits secondary to traumatic spinal cord injury were evaluated. In 52 instances (9.1%), the diagnosis was initially missed for a varying period of time. The records confirmed that 34 of the patients in whom the diagnosis was missed underwent a therapeutic intervention that was inappropriate to their condition and were therefore mismanaged by the referring hospital. After detailed discussions between two senior authors, the treatment offered to 30 patients was considered negligent

Submitted for publication June 22, 2001.
Accepted for publication December 21, 2001.

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Table 1 **Vertebral Level of the Missed Injury Population Studied**

Vertebral Level	No. of Lesions
C1/2	1
C3–C6	28
C7/D1	4
T	14
L	5

and inappropriate. There were 40 men with a mean age of 43.2 years (range, 17–81 years) in whom the spinal cord injury was initially missed. The average age of the 12 women was 59 years (range, 25–92 years). The vertebral level of these missed lesions is shown in Table 1. The distribution of the incidence of missed lesions during the last 10 years is shown in Figure 1.

Of the 52 patients in whom SCI was initially missed, 30 suffered the injury after road traffic (car/motorcycle) accidents. Minor falls (n = 7), falls down a flight of stairs (n = 7), and falls from a significant height (n = 6) were other important causes of paralysis in this group. One patient suffered tetraplegia after a diving injury. A heavy beam fell on the back of one patient, resulting in paralysis. Dislocation of the cervical spine resulting in tetraplegia occurred in one individual whose head and neck were forcefully restrained (head lock) by the police during a struggle.

The paralysis caused by spinal cord injury was unrecognized even after referral to specialists such as neurosurgeons and orthopedic surgeons in 33 of 52 (63%) instances. Spinal column injury and/or SCI was unrecognized by accident and emergency units in 17 patients. Failure to recognize SCI occurred both in district general hospitals (n = 28) and teaching hospitals (n = 19). The paralysis was unrecognized by general practitioners in two instances. In this study, paralysis was not recognized by a medical team abroad on two occasions. One individual who suffered an injury in a community hospital developed paralysis gradually over several days. The median time to recognition of SCI was 4 days (range, 10 hours to 6 weeks).

In 26 of 52 patients (50%), mismanagement of SCI resulted in neurologic deterioration. In seven of these patients, the neurologic deficit at the time of initial presentation to the accident and emergency unit was minimal. The remaining 19 had significant neurologic deficit, which deteriorated after mismanagement. In nine patients, mismanagement caused the neurology to deteriorate to complete paralysis. Six patients died as a direct result of the delay in diagnosis. Eight patients had more than one vertebral fracture. Even though one of the vertebral column injuries was initially recognized, the second injury remained unrecognized in these patients, resulting in additional neurologic disability.

Thirty-six (36 of 52) patients (69%) had multisystem injuries, and nearly a third had significant head injury. Sixteen were admitted to the accident and emergency unit with an altered Glasgow Coma Scale score (<13–15). Thirteen of them required ventilation soon after admission, and this restricted an opportunity for a secondary survey. Nine of the patients were under the influence of alcohol when first seen. Seven patients were labeled hysterical at the time of initial examination.

A major cause for the delay in diagnosis seems to be related to a failure to appreciate radiologic signs. Initial radiographs were of poor quality in 18 of the 52 cases. The entire region was not visualized adequately in 11 of 52 instances. In four cases, radiographs of uninjured regions were requested. Surprisingly, in 10 of 52 of the radiographs, an obvious fracture was missed. Another 11 of 52 lesions were missed because of failure to interpret facet joint malalignment. Initial radiographs of 10 (10 of 52) patients who developed tetraplegia showed evidence of increased prevertebral soft tissue space, suggestive of hematoma. In these patients, a spinal column lesion could have been suspected if closer attention was given to the presence of increased prevertebral soft tissue shadow. Six of the patients in whom the paralysis was missed had no obvious vertebral injury on the routine radiographs, and magnetic resonance imaging (MRI) scans were required to confirm cord damage. Spondylitic changes on the cervical spine contributed to the difficulty in

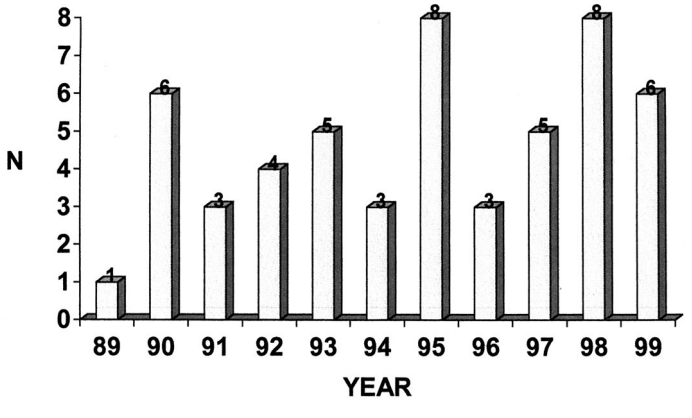

Fig. 1. *Annual incidence of missed injuries of the spinal cord during the period of study.*

the diagnosis in 14 patients. Five of the patients had ankylosing spondylitis, and this probably led to a difficulty in obtaining and assessing the radiograph. In eight patients, no radiograph was taken when the patient presented with the SCI, since the treating physician did not feel it was warranted. There was one patient who was first seen in Turkey, whose initial radiographic details were not available. Radiodiagnostic difficulties arose in most instances as a result of a combination of more than one of the factors listed above.

CASE REPORTS

Case 1

A 20-year-old man was found wandering during the early hours. He was picked up "for his own safety" by the police, who thought that he was under the influence of alcohol. He "collapsed" when the police held him in a headlock grip to "avoid him injuring his head against a brick wall." He was subsequently taken to the accident and emergency department, were he was allowed to "sleep it off." When he woke up in the morning, he complained of numbness and weakness in his lower limbs. A psychiatrist was called in, who attempted to make him stand. When he collapsed onto the floor, he was left there for a while, so as to "encourage him to stand." Twenty-four hours after the injury, a radiograph of the spine was eventually taken, which showed a C5 fracture, which was subsequently stabilized. Surprisingly, despite several errors of judgment, the patient made a good neurologic recovery.

Case 2

A 75-year-old man was found to have a T5 fracture after a road traffic accident, and as the sensation above the nipples was normal, his neurology was assessed to be "T4/5 incomplete." It was only 5 days later, on transfer to our unit, that the deficits in the upper limb were recognized, and a C6/7 bifacetal dislocation was identified on the cervical radiograph.

DISCUSSION

Significant advances in the management of acutely traumatized patients have occurred since a previous study was carried out in 1981.[1] The incidence of missed spinal column injuries with or without neurologic deficits in patients admitted to other trauma centers varies between 8% and 30%.[2,5,9,11] However, we were surprised to find that, despite the introduction of Advanced Trauma Life Support courses and other instructional lectures to accident and emergency medical officers, the incidence of missed spinal cord injury had risen to 9% in this study—compared with 4% in the previous study.[1]

Our study also identified that a high proportion of patients in whom injury to the spinal cord was unrecognized initially deteriorated as a result of unwarranted interventions, often in the accident and emergency departments. Earlier studies show that up to 10% of patients with cervical column injury who initially did not have any neurologic deficit deteriorated after their admission to a trauma center.[9] The need to minimize the secondary damage to the spinal cord occurring in the trauma centers/accident and emergency departments cannot be overstated in this group of patients.

This study, like the previous one, identified several factors that contributed to a failure to recognize a spinal column/cord injury in the accident and emergency department.[1] These include ambience and circumstances surrounding the injury, inadequate neurologic assessment, associated injuries, and radiographic or radiodiagnostic errors.

Ambiance and Circumstances Surrounding the Injury

The potential for spinal cord injuries should be suspected in all cases of high-velocity road traffic accidents. Unguarded falls, especially when under the influence of alcohol, diving accidents, and rugby accidents all have the potential to result in significant neurologic deficit. Injuries such as hyperextension dislocation and the Taylor mechanism to the cervical spine, often seen in elderly patients, can result in significant neurologic deficits without any obvious evidence of bony injury.

Patients with preexisting neurologic conditions such as multiple sclerosis, spina bifida, stroke, and cerebral palsy should be assessed carefully when they present with increased weakness after a minor fall. Often, clinicians attribute the presenting symptoms of weakness to the premorbid abnormality, thereby ignoring the potential effects of spinal cord injury. Similarly, patients with ankylosing spondylitis,[5] rheumatoid arthritis, and cervical spondylitis[12] should be carefully assessed for neurologic deficits when they present to the accident and emergency department after an "incidental" fall.

Patients with a vertebral fracture at one level may have a concomitant lesion at another level (8 of 52 in our series), and if appropriate precautions are not taken, this can lead to further cord damage at a different level. In patients who have had a spinal column injury at one level, it is therefore important to screen the entire spinal column to exclude a dual lesion.[5,13,14]

Clinical Examination

While examining the patient, there are several subtle clinical signs that could indicate a significant spinal cord lesion. Varying degrees of torticollis with or without sternocleidomastoid spasm should alert the clinician to the possibility of a facet joint dislocation. Paraspinal bruising or hematomas may indicate a serious posterior interspinous ligamentous injury/bony injury. Pseudopriapism because of autonomic vasoparesis is strongly suggestive of the presence of spinal cord injury. The presence of hypotension associated with bradycardia, as opposed to hypotension and tachycardia seen in multisystem injuries with blood loss, should alert the clinician to suspect a spinal cord injury. A paradoxic respiratory pattern in the absence of flail segments is often seen in

patients with cervical and high thoracic injuries, and one should be alert to notice such changes.[1]

It has been shown in several series that cervical spine radiographs are usually unnecessary when an alert, mentally unimpaired, neurologically intact patient denies neck pain.[12,15,16] However, there were two elderly patients in our series who had no neck pain, but had neurologic deficits that were missed. The presence of neck or back pain should lead one to suspect spinal cord injuries—especially if accompanied by root pains.

While examining a conscious trauma victim in the emergency center, a detailed motor and sensory examination including the perianal region is essential to exclude paralysis. Neurologic deficits, especially if they are minimal, are unrecognized if systematic examination is not performed. Involuntary movements/fasciculation of muscles in the paralyzed lower extremity may be seen for a varying period of time after spinal cord injury. This should not be interpreted as normal voluntary power in the lower limbs. Similarly, plantar stimulation may result in reflex withdrawal of the lower extremity or contraction of the hip adductors. Such involuntary flexion withdrawal response should not be mistaken for the presence of cortically controlled voluntary movements of people with an uninjured spinal cord.

Brief and cryptic neurologic assessments made in the accident and emergency unit, implying that all groups of muscles in one or more limbs have normal power (or sensation), when specific/detailed examination was not carried out, encourages the legal team to draw erroneous conclusions.[17] If detailed assessment could not be performed, it is more appropriate to state "Limited examination-? Normal. To be assessed later." Medical entries made without a thorough neurologic assessment, that imply that the patient with spinal cord lesion had relatively normal movements/sensation, may encourage the patients and their legal advisors to allege that the health authority either caused/contributed to subsequent "loss of function"—even in patients who were significantly paralyzed from the onset.

A common mistake made while examining the sensory level is to evaluate sensory deficits along the midline of the body. In the chest, one should be aware of the fact that preservation of sensation over the manubrium sterni is due to C4 innervation (supraclavicular nerves) rather than from the intercostal nerves at T3/4. When the sensation over the trunk is assessed, it should follow specific well-established landmarks—from the anterior superior iliac spine (T12–L1), toward the umbilicus (T10), and then toward the axilla (T2)—rather than up along the midline. This assessment is very important when dealing with patients with concomitant lesions—thoracic and cervical.

When a patient with altered sensorium because of alcohol, drugs, or head injury develops urinary retention or motor weakness, it should be treated with appropriate clinical suspicion for SCI. In this series, 7 of 52 patients with paralysis were labeled as hysterical (e.g., see case 1).

Before making a diagnosis of hysterical paralysis, a detailed history and neurologic examination is essential. Patients with hysterical paralysis often have friends or relatives who have had spinal cord injuries and paralysis in the past. The individual manifesting conversion reaction is generally apprehensive. The individual presenting with conversion reactions and paralysis derives "primary gain" by keeping an internal conflict or need out of awareness. There is usually some "secondary gain" that may or may not be obvious. Neurologic deficits often do not follow an anatomic pattern. Sensory loss tends to be transverse and "complete," but varies on repeated examination. Ratchety response to manual muscle testing, inconsistency in examination, and slow motion should alert the examiner to the possibility of nonorganic weakness.[18] On attempting to check the quadriceps power in a supine patient, with the knee and hip flexed at 90 degrees, the patient will fail to extend the knee, but he may be able to hold the leg at 90 degrees, even when the support to the calf is removed. On attempting to check for the hip adductors, with the hip flexed and semiabducted, the patient will hold the limb in the semiabducted position, and the limb will not flop to the side of the bed, as would otherwise be expected in a patient with adductor weakness. Caution must be taken in the diagnosis of conversion disorder, as findings such as indifference, patchy nonanatomic sensory loss, and suggestibility can occur in some neurologic diseases.

Associated Injuries

Paralysis resulting from spinal cord injury is difficult to assess in patients who are unconscious because of head injury (12 of the 52), intoxicated, or critically ill with multiple injuries.[1–3,6] The pressures on the medical team during any major resuscitation are well known. In the severely injured patient, the medical team's efforts are directed toward resuscitation, and the clinical effects of the underlying spinal cord injury may be overlooked.[1] Thus, patients may receive large fluid infusions to correct hypotension, which may be a direct result of paralysis (neurogenic hypotension), and unrelated to any blood loss.

Immobilization of the spinal column is essential until a formal reevaluation of the patient (secondary survey) is carried out after resuscitation. Sadly, on a few occasions, secondary surveys are not carried out, since resuscitated patients are transferred to the intensive care/high-dependency units. The limited clinical impressions obtained during the primary survey may be deemed adequate for several days. This practice can lead to a failure to recognize the underlying spinal column/spinal cord injury.

Radiographs

Radiologic and radiodiagnostic difficulties in recognizing spinal column injuries, particularly in the cervical spine, have been addressed by several authors. Lateral views of the cervical spine, although indispensable, fail to visualize cervical spine injuries in approximately 15% to 25% of patients.[3]

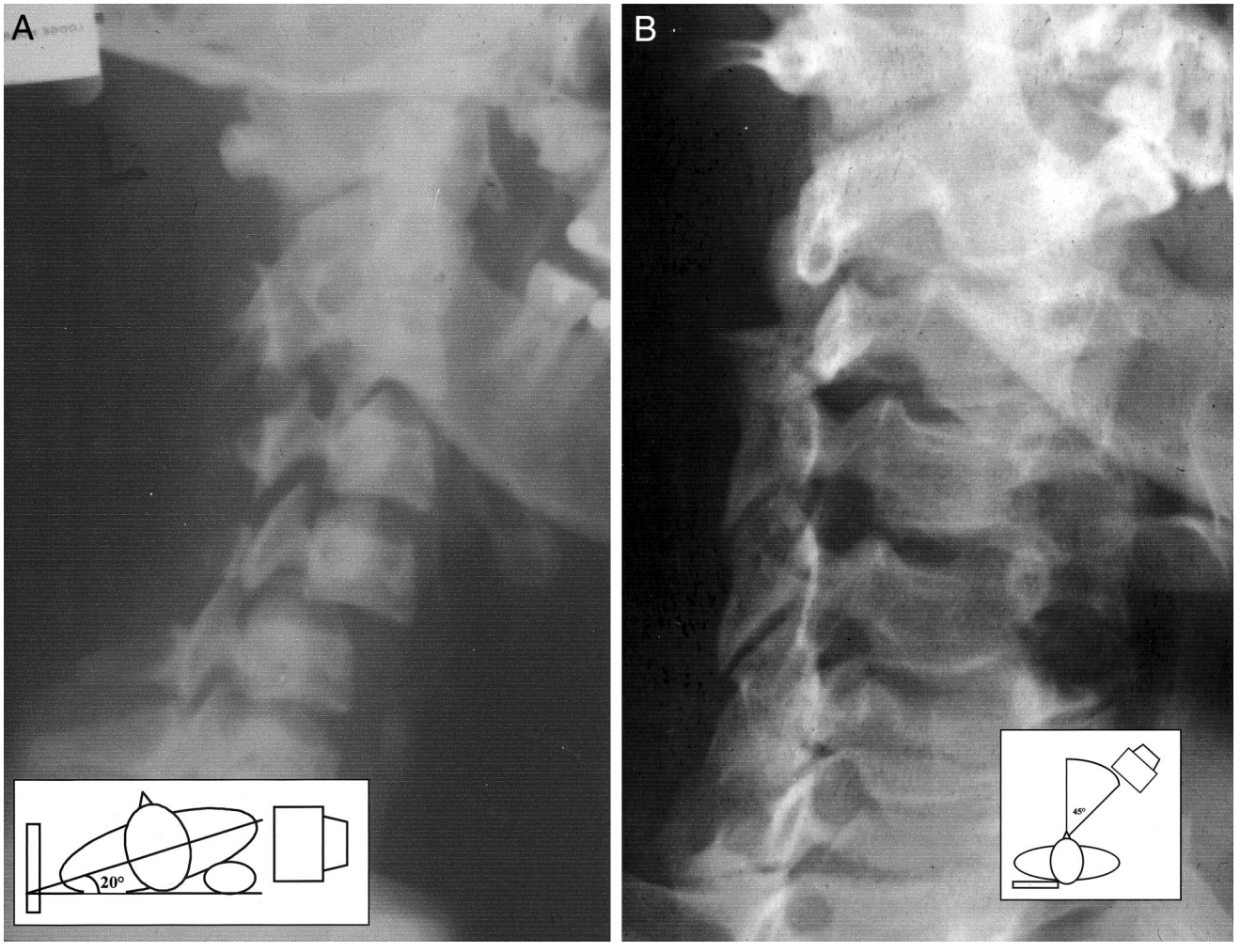

Fig. 2. *(A) Lodge Moor oblique view showing dislocation of C5/6 facet. These radiographs were obtained by inserting a pillow under one or the other shoulder. The facet seen in these radiographs correspond to the shoulder that is not elevated (see* inset*). (B) Oswestry oblique view showing dislocation of the C3/4 facet joint. These radiographs were obtained by sliding a radiograph cassette under the contralateral shoulder and neck while the x-ray beam was aimed at 45 degrees from the sagittal plane, centered at the anterior margin of the middle of the sternomastoid muscle (see* inset*).*

The recommended series of five cervical spine radiographs—anteroposterior [AP], lateral, and oblique views (Fig. 2), and the open mouth view—is said to improve the diagnostic accuracy derived from radiographs to about 92%.[2,3,7,19]

While studying the lateral views of the spine, the physician must look for the alignment of the anterior margins of the vertebral body, the posterior margin of the body of the vertebrae, the anterior and posterior heights of the vertebrae, the apophyseal joints, the integrity of the spinous processes, and the laminar line.[20] The relationship with the vertebral body above and below should be scrutinized. Anterior translation of more than 3 mm could denote structural abnormality.[21,22] In children, however, a forward glide of up to 4 mm is considered normal, and is not indicative of instability.[5] In the upper cervical region, a separation of more than 3 mm between the odontoid process and the anterior arch of the atlas in adults, and 5 mm in children, is indicative of ligamentous damage at that level, and requires reappraisal of the clinical and radiologic evidence.[5,23]

Attempts must be made to visualize the cervicothoracic junction in the lateral projections. Gentle traction of the arms to depress the shoulder is often valuable to achieve better visualization of the lower cervical spine. However, such traction should not result in extension of the neck. Undue traction can result in neurologic deterioration, particularly in patients who have preexisting conditions such as spondylitic myelopathy or ankylosing spondylitis[24] (Fig. 3). If the cervicothoracic junction cannot be visualized properly, swimmer's views, lateral tomograms, or computed tomographic scans may be needed. A cervical spine radiographic evaluation cannot be said to be complete without visualizing the cervicothoracic junction.[7,25]

An increase in the soft tissue shadow in front of the cervical spine is a subtle sign of spinal column injury. A soft

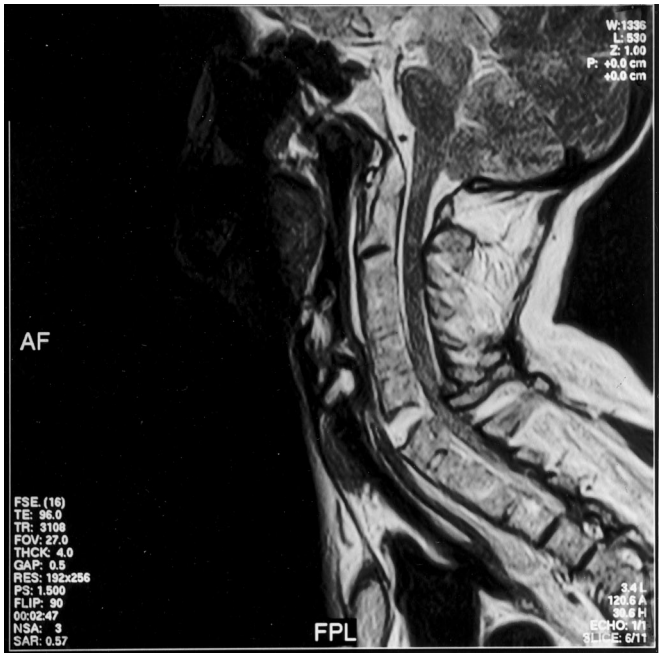

Fig. 3. *This 60-year-old who had a fixed downward gaze because of ankylosing spondylitis suffered a fall. Initial radiographs showed details up to C4. Pulled lateral radiographs showed details up to C6 body only. During MRI scan evaluation, the unsupported head gradually extended to result in C6/7 complete tetraplegia.*

tissue shadow of 0.5 cm at C4 and 1 to 2 cm below that is accepted as normal.[5,22,26] At C1, there is usually a concavity above and below the neural arch of the atlas, although at the atlas itself, there is a slight convexity. If there is any alteration in this pattern, a craniocervical injury should be suspected.[27]

In the spondylitic spine, examination and evaluation may be difficult. Any undue widening of disc space, separation of osteophytes, teardrop fractures, or fractures of the spinous processes should alert the clinician to the possibility of a major ligamentous disruption.

Careful scrutiny of the AP view is needed to look for malalignment of the spinous process, which may indicate a unilateral facet joint dislocation. Fractures of the lateral mass, neural arch, and the vertebral body can also be identified on the AP film. Widening of the interpedicular distance indicates disruption of the posterior column and to a hyperflexion injury.

An open mouth view is needed in high-risk patients, to view the odontoid, the lateral masses of the axis, and the neural arch of the atlas. Open mouth views are impossible to obtain in unconscious patients. A discrepancy of more than 2 mm in the space between the odontoid and the lateral masses on the two sides is suggestive of a C1 lateral mass fracture with displacement. Intubated patients, however, may pose a difficulty, as proper imaging may be difficult. The spine should be protected until appropriate films can be obtained.[5]

Supine oblique views are very useful in the acute stage for visualizing the facet joints and the laminar fractures. It is especially useful in identifying the dislocated facet joint in unilateral facet joint dislocations. These views are essential in all high-risk patients.

However, it was rather disconcerting to note that one of the most common errors in this series of 52 missed lesions was a failure to notice an obvious fracture on the radiograph, which occurred in 10 instances. Failure to recognize facet joint disorders, noted in 11 patients, seems to be another common problem. Pulled lateral views and oblique views help to visualize the lower cervical vertebrae better if standard lateral views prove to be inadequate. Radiographs were considered unnecessary in eight instances.

The propensity of certain cervical spine fractures to escape detection on radiographs was reported by Clark et al., who found delayed radiologic diagnosis in 23% of odontoid, 16% of teardrop, 14% of facet, and 10% of hangman's fractures.[28] In other injuries to the spine, such as disc herniation, central cord or anterior cord injuries secondary to hyperextension injuries, and vascular infarction, where conventional radiographs may not identify any abnormality, MRI scans will be needed to detect such soft tissue injuries.

There is no universally accepted definition of stability, and therefore designation of a particular injury as unstable can vary among authors. In the thoracic and lumbar spine, Denis described the three-column theory in an attempt to understand the biomechanics of the spine.[29] On the basis of sound biomechanical principles, White et al. identified several radiographic features which, in combination with other factors, suggest instability in the cervical spine. These include loss of anterior structural integrity, loss of posterior structural integrity, subluxation greater than 3.5 mm, kyphosis greater than 11 degrees, and disc widening or narrowing.[21] Although all these radiographic signs may be absent, the presence of significant/localized prevertebral soft tissue shadowing on cervical spine radiographs,[5,22,26] severe neck pain, and neurologic deficits should alert the clinician to the possibility of an occult unstable injury, and appropriate precautions should be taken.

A two-phase analysis with both static and dynamic testing is generally needed to confirm the stability of a spinal column injury. Immediate posttrauma flexion-extension views are inappropriate and impractical, as most patients will not be able to perform the maneuver adequately, and occasionally this may lead to further neurologic deterioration.[3] Dynamic views obtained prematurely can precipitate spinal cord injury (Fig. 3). Flexion-extension views carried out between 2 and 6 weeks after the injury could rule out instability in such patients and the spine protected in some manner until then. Erect flexion-extension views may have to be obtained if doubt still exists on supine dynamic views. In most instances, however, a delay of 2 to 6 weeks may not be in the best interest of the patient, and computed tomographic scanning or MRI should be performed if bony/ligamentous instability is suspected.

CONCLUSION

Missed injuries of the spinal cord seldom occur because of an isolated cause. In many instances, a failure to recognize spinal cord injury occurs because, in trauma victims, clinicians anticipate spinal column injury to accompany paralysis, and in the absence of a radiologically demonstrable bony lesion they often attribute the observed neurologic signs to preexisting locomotor dysfunction such as arthritis or incidental conditions such as head injury, drug use, and so forth. Radiographs should be ordered appropriately and reviewed critically, but one should not rely on the presence of radiographic changes to make a diagnosis of spinal cord injury. The diagnosis of spinal cord injury is made on the basis of clinical examination. When in doubt, the spine should be immobilized until the diagnosis is clear. With adequate care, it is possible to detect many lesions that would otherwise have been missed. Failure to provide adequate management as a result of missed injury not uncommonly results in expensive medical litigation.[1]

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