0022-5282/00/4804-0724
The Journal of Trauma: Injury, Infection, and Critical Care

Vol. 48, No. 4
Printed in the U.S.A.

Nonskeletal Cervical Spine Injuries: Epidemiology and Diagnostic Pitfalls

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Background: **Cervical spine injuries are the most commonly missed severe injuries with serious implications for the patient and physician. The diagnosis of subluxations or spinal cord injuries in the absence of vertebral fractures, especially in unevaluable patients, poses a major challenge. The objective of this study was to study the incidence and type of cervical spine trauma according to mechanism of injury; identify problems and pitfalls in the diagnosis of nonskeletal cervical spine injuries.**

Methods: **Retrospective study of all C-spine injuries caused by traffic accidents or falls admitted over a 5-year period at a large Level I trauma center. Data were obtained from the trauma registry, review of patient charts, and radiology reports.**

Results: **During the study period, there were 14,755 admissions due to traffic injuries or falls who met trauma center criteria. There were 292 patients with C-spine injuries, for an overall incidence of 2.0% (3.4% in car occupants, 2.8% for pedestrians, 1.9% for motorcycle riders, and 0.9% for falls). The incidence of C-spine injuries in patients with a Glasgow Coma Scale score of 13 to 15 was 1.4%, 9 to 12 was 6.8%, and in ≤8 was 10.2% ($p < 0.05$). Of C-spine injuries, 85.6% (250 patients) were a vertebral fracture, 10.6% of the injuries (31 patients) were subluxation without fractures, and 3.8% (11 patients) were an isolated spinal cord injury without fracture or subluxation. Of the 31 patients with isolated subluxations, one-third required an early endotracheal intubation before clinical evaluation of the spine, because of associated severe head injury or hypotension. Adequate lateral C-spine films diagnosed or suspected 30 of the 31 subluxations (96.8%). The combination of plain films and computed tomographic (CT) scan diagnosed or suspected all injuries. Of the 11 patients with isolated cord injury, 27.3% required early intubation before clinical evaluation of the spine. The diagnosis of cord injury was made on admission in only five patients (45.5%). In three patients, the neurologic examination on admission was normal and neurologic deficits appeared a few hours later. In the remaining three patients (two intubated, one intoxicated), the diagnosis was missed clinically and radiologically.**

Conclusions: **Isolated nonskeletal C-spine injuries are rare but potentially catastrophic because of the high incidence of neurologic deficits and missed diagnosis. In subluxations, the combination of an adequate lateral film and CT scan was reliable in diagnosing or highly suspecting the injury. A large prospective study is needed to confirm these findings, before a recommendation is made to remove the cervical collar if the findings of these investigations are normal. However, in isolated cord injuries, the diagnosis was often missed because of associated severe head trauma and the low sensitivity of the plain films and CT scans.**

Cervical spine (C-spine) injuries are the most commonly missed severe injuries with potentially catastrophic consequences for the patient and major medicolegal implications for the surgeon or the emergency room physician. The initial evaluation of the C-spine is still an unresolved and controversial issue. The diagnosis of nonskeletal C-spine injuries is an even more difficult problem. In the present study, we investigated the epidemiology and diagnostic pitfalls of isolated nonskeletal C-spine injuries. This group of injuries includes subluxations or cord injuries without associated vertebral fractures.

PATIENTS AND METHODS

This is a retrospective study and included all blunt trauma patients injured in traffic accidents or falls with C-spine injuries admitted at the Los Angeles County and University of Southern California Medical Center during a 5-year period (January of 1993 to December of 1997). Data were obtained from the trauma registry, which is maintained by seven full-time trained nurses, and from patient charts and radiology reports. The spinal injuries were classified into three groups: group A, which included patients with C-spine fractures; group B, which included subluxations without fractures; group C, which included spinal cord injuries without any evidence of associated fractures or subluxations. The study included all injuries identified during the hospitalization of the victims. No postdischarge follow-up data was available. Detailed analysis was restricted to groups B and C.

RESULTS

During the 5-year study period, there were 14,755 admissions injured in traffic crashes or falls meeting trauma center criteria. Overall, there were 292 patients with cervical spine injuries, for an overall incidence of 2.0%. The C-spine injury rate according to mechanism is shown in Table 1. Of the 292 C-spine injuries, 250 patients (85.6%) had vertebral fractures, 31 patients (10.6%) had subluxations without fractures, and 11 patients (3.8%) had isolated spinal cord injury without

Submitted for publication May 8, 1999.
Accepted for publication December 30, 1999.
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TABLE 1. **Incidence of C-spine injury according to mechanism of injury**

Mechanism of Injury	Number of Admissions	Number of C-Spine Injuries (%)
MVA	3,893	131 (3.4)
Pedestrian (including bicycle)	3,196	90 (2.8)
Motorcycle	482	9 (1.9)
Falls	7,184	62 (0.9)
Total	14,755	292 (2.0)

fractures or ligament injuries. The epidemiology of the three groups of C-spine injuries is shown in Table 2. The overall incidence of C-spine injuries, was not statistically different between motor vehicle crashes, pedestrians, and motorcyclists (χ^2 test, $p > 0.05$), although in falls, the incidence was significantly lower than the rest of the groups ($p < 0.05$) (Table 1). The incidence of the various types of C-spine injury (fractures vs. subluxations vs. isolated cord injury) was again similar in the three groups of traffic crashes (Table 2).

The incidence of C-spine trauma according to Glasgow Coma Scale (GCS) score is shown in Table 4. Patients with lower GCS score had a significantly higher incidence of spinal injuries ($p < 0.05$). Overall, 75 patients (25.2%) with spinal injury had neurologic signs related to the C-spine on admission. Fifty of 250 patients with vertebral fractures (20%) and 14 of the 31 patients (45.2%) with subluxations had neurologic signs on admission ($p = 0.003$). The mean age of patients with fractures, subluxations, and isolated cord syndromes was 34, 39.3, and 43.5 years, respectively. Epidemiologic and clinical parameters in the three groups of patients are shown in Table 3.

Patients with Subluxations without Fractures

There were 31 patients (0.2% of all traffic crashes or falls admissions or 10.4% of all C-spine injuries) with C-spine subluxation and no associated fracture. Details are shown in Table 2.

The mean age of this group of patients was 39.3 years, and there were 22 male and 9 female patients. Seven of the patients (22.6%) had a systolic blood pressure $\leq$ 90 mm Hg, and 9 patients (29.0%) had GCS score $\leq$ 12 with severe intracranial pathologic conditions (head Abbreviated Injury Score $\geq$ 3). Ten patients (32.3%) required prehospital or emergency room intubation before clinical evaluation of the spine, because of associated major head injury or severe hypotension. Associated injuries to the torso were found in 9 patients (29.0%), and pelvic or long-bone fractures were present in 10 patients (32.3%). Ten patients (32.3%) had no significant associated extracervical spine injuries. Fourteen patients (45.2%) had neurologic signs related to the C-spine injury (12 patients had both motor and sensory deficiencies and 2 patients had paresthesia only without motor deficits).

TABLE 3. **Epidemiologic and clinical parameters of 292 patients with C-spine injuries**

Type of C-Spine Injury	Number	Mean Age (yr)	GCS $\leq$ 12 (%)	Endotracheal Tube Prehospital or in ER[a]
Vertebral fracture	250	35	83 (33.2)	32 (12.8)
Subluxations without fractures	31	39.3	9 (29.0)	10 (32.3)
Spinal cord injury without bone or ligament injuries	11	43.5	3 (27.3)	3 (27.3)

[a] ER, emergency department.

Adequate lateral C-spine films (C1-T1) diagnosed or highly suspected 30 of the 31 subluxations (96.8%). In one case (3.2%), the films missed a C5–6 subluxation. This patient was involved in a motor vehicle crash and had severe head trauma (GCS score = 3), chest trauma, and multiple long-bone fractures. Our protocols mandate routine cervical spine computed tomographic (CT) scan for all unevaluable patients with suspicious mechanism of injury. The CT scan showed the subluxation. The plain radiography was suspicious of subluxation in another six patients, but further investigations by means of flexion/extension views did not show any abnormality.

A helical CT scan of the C-spine was performed in 17 patients with proven subluxation. It was diagnostic for 15 patients (88.2%) but missed subluxations for 2 patients (11.8%). The combination of plain radiography and CT scan diagnosed or highly suspected all subluxations. Flexion-extension views were required in seven cases for confirmation of the diagnosis. A magnetic resonance imaging (MRI) scan was performed on seven patients with proven subluxations and was diagnostic in all cases.

Four patients (12.9%) died from associated severe head trauma. Of the 14 patients with neurologic deficits, 12 patients recovered completely and 2 patients remained permanently paralyzed (1 quadriplegic, 1 paraplegic).

Patients with Isolated Cord Injury

There were 11 patients with isolated C-spine cord injury without associated fracture or subluxation (0.07% of all traffic crashes or falls admissions, 3.5% of all C-spine injuries).

TABLE 2. **Incidence and type of C-spine injuries according to mechanism**

Mechanism of Injury	Number of Trauma Admissions	Total No. of Spinal Injuries (%)	C-Spine Fractures (%)	Subluxation without Fracture (%)	Spinal Cord Injury without Bone or Ligament Injury (%)
MVA	3,893	131 (3.4)	111 (2.9)	16 (0.4)	4 (0.10)
Pedestrians (including bicycles)	3,196	90 (2.8)	80 (2.5)	8 (0.3)	2 (0.06)
Motorcycles	482	9 (1.9)	7 (1.5)	0	2 (0.4)
Falls	7,184	62 (0.9)	52 (0.7)	7 (0.1)	3 (0.04)
Total	14,755	292 (2.0)	250 (1.7)	31 (0.2)	11 (0.07)

TABLE 4. Association between GCS and C-spine injury

Injury Severity (GCS score)	Total Number of Trauma Admission	Number of Pts[a] with C-Spine Injury (%)
13–15	14,088	198 (1.4)
9–12	383	26 (6.8)
≤8	667	68 (10.2)

[a] Pts, patients.

The incidence according to mechanism of injury is shown in Table 2. The mean age was 43.5 years, and all victims were male. All patients had a systolic blood pressure ≥ 90 mm Hg on admission. Three patients (27.3%) had a GCS score ≤ 12 and head AIS ≥ 3 and required emergency room intubation before clinical evaluation of the spine. Overall, five patients had significant extra cervical injuries (three head injuries, two long bone fractures) and six had no other associated injuries.

The isolated cord injuries included six central cord syndromes and five other cord contusions/hematomas. The diagnosis was made on admission in only five patients (45.5%). In three patients, the initial neurologic examination was normal and neurologic deficits appeared a few hours later. MRI studies showed spinal cord injury. In another three patients the diagnosis was delayed. One of the victims was a 75-year-old man who was involved in a motor vehicle crash. The admission GCS score was 4 and required emergency room endotracheal intubation. The C-spine radiology films and CT scan did not show any acute abnormality, although there were degenerative changes. He was extubated 4 days later with a GCS score of 15, and complained of weakness in all extremities, more severe in the arms. A MRI scan diagnosed central cord syndrome. He remained in the SICU for 13 days and in hospital for 36 days. He improved significantly and on discharge he had mild upper extremity weakness. The second patient was a 60-year-old man who fell from stairs while drunk (alcohol 0.347). On admission, his GCS score was 15, he complained of mild neck pain and weakness in all four extremities. The plain C-spine films and CT scan showed osteoarthritic changes but no acute pathologic condition. The extremity weakness was attributed to alcohol intoxication. Two days later, a MRI scan was performed because of persisting weakness and confirmed the diagnosis of central cord syndrome. His hospital stay was 8 days long, and he was discharged without significant improvement. The third patient was a 36-year-old man who was involved in a motor vehicle crash. His admission GCS score was 7, and he required emergency room intubation. The head CT scan showed a skull fracture and a small extradural hematoma. C-spine radiology films did not show any acute or chronic abnormality. He was extubated 7 days later with a GCS score 15 and weakness in all four extremities. MRI diagnosed spinal cord contusion. He remained in hospital for 13 days and was discharged with unchanged extremity weakness.

The C-spine films did not show acute lesions in any of the 11 patients, although degenerative changes were shown in four patients. The diagnosis of cord injury was confirmed by MRI scan in all cases. A CT scan was performed in only four patients and was diagnostic in two of them.

Overall, two patients were operated on for decompression of the cord. None of them improved postoperatively, and they remain permanently quadriplegic. The remaining patients were treated with steroids. Six patients improved and three remained unchanged at the time of discharge.

DISCUSSION

The evaluation of the C-spine, especially in obtunded patients is one of the most difficult and controversial issues in trauma. Missing a spinal injury can be catastrophic, for both the patient and physician. The incidence of missed injuries in organized trauma centers ranges between 4 and 8%.[1,2]

In the awake, alert, and clinically not intoxicated trauma patient, the evaluation is usually easy and safe, i.e., asymptomatic patients do not need radiologic evaluation.[3,4] Symptomatic patients are evaluated by means of three-view cervical radiograms and in the appropriate cases by focused CT scan, flexion/extension views, or MRI scan. However, for obtunded patients, especially for victims with multiple injuries with associated severe head injuries requiring prolonged mechanical ventilation, the evaluation of the C-spine becomes a challenging and controversial issue. Clearing the C-spine by plain radiography is a common but potentially dangerous practice. In a recent survey of 25 intensive care units in the United Kingdom, in 16 units the C-spine immobilization in unconscious patients was stopped on the basis of normal lateral views. Five units required a normal lateral and anteroposterior view, and four units required a normal lateral, anteroposterior, and open mouth peg view.[5] Such practice is not acceptable and should be condemned. In most centers the standard policy is to keep unevaluable patients in C-collar and spinal precautions until they improve and clinical evaluation becomes possible. Although such policy is practical in patients who remain unevaluable for only a few days, its application in patients who cannot be evaluated clinically for a prolonged period of time is questionable and suboptimal. Cervical collars do not provide sufficient neck immobilization, often interfere with patient care, and have complications. Spinal precautions preclude the use of specialized beds and dictate a continuous horizontal position, which increases the incidence of respiratory complications. Some studies recommended fluoroscopy of the cervical spine with passive flexion/extension views under close neurosurgical supervision.[6] However, most surgeons feel uncomfortable manipulating the spine of an unconscious patient and would not allow this practice in their institutions. More recently, with the development of helical CT scan, there have been suggestions for routine CT scanning of the C-spine in all unevaluable patients.[7] In a recent prospective study from our center, Berne et al.[8] performed routine C-spine radiography and helical CT scans in 58 high-risk patients requiring ICU admission and CT scan examination of another body area. A cervical spine injury was diagnosed in 20 patients (34%). The CT scan detected 18 of these injuries (90%), and the plain radiography diagnosed 12 of them (60%). The combination of helical CT and plain radiography diagnosed all injuries. Currently, our protocols include routine CT scan examination

of the spine as part of the primary evaluation of the high-risk patient with multiple injuries.

The most unresolved issue is the diagnosis of nonskeletal C-spine injuries in clinically unevaluable patients with multiple injuries. In the present study, 0.3% of all blunt trauma admissions or 14.4% of all C-spine injuries had ligament or spinal cord injuries without associated fractures. Thirty-one percent of these patients required emergency intubation for severe head injuries or shock, before clinical evaluation of the spine. In the present study, an adequate lateral film diagnosed or suspected 96.8% of the 31 subluxations. A helical CT scan with reconstructed views diagnosed 88.2% of the injuries. The combination of the two investigations diagnosed or suspected all injuries. Once a pathology is suspected, the diagnosis becomes easy by choosing the next appropriate test, i.e., flexion/extension views or MRI scan. Similar conclusions about the sensitivity of this combination in detecting cervical spine injuries have been reported by Borock et al.[9] and Berne et al.[8] If these findings are confirmed in large prospective studies, it will become possible to remove the cervical collar after plain-film and CT scan investigations. We are currently busy with such study.

The early diagnosis of isolated spinal cord injuries in the absence of fracture or subluxation in the unconscious patient with multiple injuries is very difficult. This condition was found in approximately 0.07% of all trauma admissions or 3.5% of all cervical spine injuries. The central cord syndrome is the most common pathology in this group, although anterior or posterior cord syndromes occur as well. The central cord syndrome is characterized by motor deficits in all four extremities, disproportionately worse in the upper than the lower extremities, and various degrees of sensory loss below the level of the injury. The cord damage might be caused by ischemia, hemorrhage, edema, or contusion. In many cases, the symptoms may appear or progress over a few hours or even days.[10] In the present study, 3 of the 11 cases with isolated cord injury required emergency room intubation for associated severe head injury before clinical evaluation of the spine. In another three patients, the symptomatology appeared a few hours after admission. Findings on the C-spine radiography films were normal in all cases, and the CT scan was diagnostic in only two of four cases for which it was performed. MRI was diagnostic in all cases. Early diagnosis is important to try to prevent secondary cord damage. Steroids remain the only treatment modality in most patients, although surgical decompression may be useful in selected cases. Unfortunately, with the current technology, early diagnosis may be impossible in a significant number of patients. MRI is very sensitive but it can rarely be performed in a patient with multiple injuries during the acute stage.

In summary, we believe that all severe patients with multiple injuries should by evaluated by routine CT scan and plain radiography of the cervical spine. If these studies are normal, the cervical collar may be removed if the patient is expected to remain unevaluable for many days. However, this recommendation should be confirmed in much larger prospective studies. This recommendation is more stringent than the East Association for the Surgery of Trauma guidelines, which require normal plain films and CT scan of C1-2 for spinal collar removal.[11] Some injuries with isolated cord injury may be missed, but in these cases, the cervical collar does not offer any benefit because of the absence of fractures or subluxations.

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