

Evaluation of spine injury in blunt trauma

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Although prehospital trauma guidelines call for spine immobilization for many trauma victims, there is a lack of clarity in medical institutions as to how trauma or emergency medicine physicians should proceed to remove cervical immobilization devices (CIDs) and “clear” the spine. Despite wide variations in physicians’ approaches to such matters, however, certain specific aspects of vertebral assessment in such circumstances are well documented. The authors describe and explore several of these issues with respect to initial approach to the immobilized patient, clinical clearance of the spine, radiographic evaluation of the vertebrae in victims of blunt trauma, management of spine tenderness or pain, removal of CIDs, and indications for subspecialty consultation. Critical care physicians should be reminded that the responsibility lies with them for removing CIDs and halting other spine precautions—underlying the importance of careful consultation with radiologists and other specialists.

(Key words: cervical spine, cervical vertebrae, emergency department, prehospital worker, radiography, spinal cord injury, spinal clearance, spine precautions, trauma, vertebrae)

Current prehospital trauma and life support guidelines mandate an appreciation of the potential for spinal cord injury (SCI) in trauma victims. Prehospital providers rely on their knowledge regarding mechanisms of injury, coupled with physical assessment, to determine which patients require spinal immobilization. Thus many victims of trauma arrive immobilized in emergency departments with cervical immobilization devices (CIDs) in place, including cervical spine collars, long spine boards, and straps. To physicians who may not have specialized training in the care of trauma victims, it is not always apparent what combination of criteria—

including mechanism of injury, physical examination, and radiographic evaluation—is necessary to rule out spine injury, or “clear” the spine.

Although the literature defines methods to evaluate and remove non-spinal cord-injured patients from CIDs safely, the manner in which this is accomplished often varies among clinicians and institutions.

In the United States, approximately 11,000 spinal cord injuries occur annually, with men predominating (81.6%) as SCI victims.¹ The average age of spinal cord-injured patients is 32.1 years.¹ The major causes of spinal injuries are motor vehicle crashes (38.5%), acts of violence (24.5%), falls (21.8%), and sports-related injuries (7.2%).^{1,2} Because trauma patients are typically young and in good health prior to injury, SCIs often have devastating physical, emotional, and financial implications.

Patients with spinal cord injuries require a hospital stay of 60 days on average, including both the acute and rehabilitation phases.¹ In addition, the lifetime cost of caring for a patient with a spinal cord injury is approximately \$1.4 million for a quadriplegic and \$600,000 for a paraplegic.¹ SCI is also associated with a high rate of unemployment and divorce and with a decreased life expectancy—with death usually resulting from pneumonia, pulmonary emboli, or septicemia.¹

Although the care and evaluation of patients with actual or suspected SCI varies widely, some aspects of assessment and management are well supported in the literature. Understandably, clinicians have cause for concern when evaluating and attempting to clear the spine—as “missed” injuries may result in devastating consequences. Not surprisingly, therefore, there is wide variation in the use of diagnostic tools among individual practitioners and institutions.^{3,4} This variation most clearly displays itself in overuse of some resources (radiographs for all patients who arrive in spinal precautions, regardless of mechanism of injury or physical assessment) and underuse of others (inadequate imaging or errors in image interpretation). Both approaches are apt to involve increased costs and risks for all parties.

Initial approach to the immobilized patient

On arrival at the scene of a traumatic injury, the prehospital provider assesses the mechanism of injury. This assessment, often in conjunction with the prehospital provider’s own concerns about potential liability, frequently dictates that the

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patient receive full immobilization in the event that he or she has a spinal cord injury.

Ideally, immobilization ensures that no additional movement occurs during the assessment, treatment, extrication, packaging, and transport of the patient. If the patient is awake and alert, the prehospital worker also instructs the patient not to move. Once at the hospital, the patient's mechanism of injury is ascertained by the attending physician, who also performs a preliminary physical assessment to determine appropriate patient care.

It must be understood, however, that no single CID offers complete immobilization. Full spinal precautions are not in place until the patient has an appropriately sized cervical spine collar and is fully immobilized to a long spine board with a CID pad that is strapped or taped securely to the board.⁵⁻⁷ Depending on the neurologic responsiveness of the patient, it also may be necessary to use analgesics and sedation after a primary survey. When a patient is suspected of having a head injury or being severely intoxicated—or if he or she has a low-value Glasgow Coma Scale score or exhibits signs of shock—there should be a low threshold for intubation. Intubation in such cases is done not only to protect and control the airway but also to help achieve complete immobilization of the patient.

Whenever the patient requires intubation or examination of the neck or mandible, manual in-line cervical stabilization must be used. This two-person procedure requires one person to hold the patient's head steady while the cervical collar is open. At no time should traction be applied to the cervical vertebrae. Oral intubation using this technique has been shown to be safe and effective.⁸

Once immobilization is achieved and the primary survey and interventions are complete, a careful secondary survey follows. Lengthy procedures and relatively nonemergent ones, such as repair of complex lacerations, should be postponed until a complete evaluation of the cervical vertebrae has been done.

The physical examination must include an evaluation of the entire spine for obvious deformities or pain. To assess the thoracic and lumbar vertebrae, a "log-roll" maneuver must be used. This maneuver is done with at least three care providers and, optimally, more than three. One care provider holds the patient's head to maintain in-line stabilization while also directing the log-roll maneuver; the remaining care providers assist in performing the maneuver at the leader's direction. The back and spine are inspected, palpated, and percussed. Radiographic studies of the chest and thorax must be completed while spinal immobilization is maintained, which requires placing the film cassette beneath the patient on the long spine board or beneath the patient by use of the log-roll technique. Some trauma stretchers allow for placement of the film cassette beneath the stretcher, which allows for easier and more rapid completion of radiographs—the goal being to safely clear the spine as quickly as possible. It must be emphasized that once the initial evaluation of the cervical vertebrae has been per-

formed, more urgent procedures should take precedence over spinal clearance.

It is also important to note that the prolonged use of spinal immobilization is not without potential complications. Cervical collars may increase intracranial pressure in patients with head injuries and can also cause occipital decubitus.⁹⁻¹¹ Significant decubitus may also occur from prolonged use of long spine boards, and erythema may be noticed after only short periods of immobilization. Until the spine is completely evaluated and deemed to be free of injury, all precautions must be maintained; the patient must continue to be immobilized and "log-rolled"—including during diagnostic studies, while in the operating room, and while in the intensive care unit. Many institutions use thin gel pads on top of long spine boards while completion and evaluation of radiographic studies are under way, providing for patient comfort and preventing decubital ulcers.

Although the mechanism of injury cannot be used as a predictor of SCI, it can provide important clues as to the type of injury that may have occurred. Motor vehicle crashes and falls frequently result in hyperflexion injuries with rotation. Cervical fractures between C3 and C7 are typically caused by hyperflexion, rotation, or a combination of these forces.¹² Hyperextension injuries usually occur at the C6-C7 vertebral interspace. Motor vehicle crashes that occur while the patient is wearing a lap belt only—as opposed to a three-point restraint seatbelt—may cause injuries to the thoracic and lumbar vertebrae. Axial loading is frequently observed in diving injuries. Most burst fractures (axial compression fractures) in the lumbar region occur between L2 and L4.¹²

The history elicited from the patient and prehospital providers should include the mechanism of injury as well as subjective complaints (eg, radicular pain, bowel and bladder dysfunction, extremity weakness, paresthesia) and objective assessment findings (eg, paralysis).

Clinical clearance of the spine

There exists a well-defined group of trauma patients whose spines can be cleared clinically without cervical vertebrae radiographic evaluation.¹³⁻¹⁷ A recent prospective multicenter study further supported the notion that clinical criteria can reliably identify which patients require radiographic evaluation following blunt trauma.¹⁸ In avoiding overly liberal use of radiographs, there could be significant cost savings as well as decreased patient exposure to ionizing radiation.

Patients who have a physical examination with otherwise negative results for injury, and who satisfy the following criteria, may be removed from CIDs without x-ray films; all other patients need standard x-ray films for vertebral trauma:

- **Non-tender spine.** The most sensitive predictor of SCI, "tenderness" refers to palpable midline bony spine tenderness.
- **No evidence of head injury; no loss of consciousness.** Patients with traumatic brain injury are unreliable. Head injury with loss of consciousness may be associated with

injury to the cervical vertebrae in 7% to 15% of patients.^{2,3}

- **No intoxication.**
- **No distracting, painful injury.** Examples include long bone, pelvic, and rib fractures.
- **No neurologic findings or complaints.** Examples include paresthesia and weakness.
- **No other level of SCI.** An injury at one level of the vertebrae has been shown to be associated with a 15% incidence of injury at another level.¹⁹

Radiographic evaluation of the vertebrae in blunt trauma

Radiologic examination of the cervical vertebrae consists of three views; there is no role in the use of a single lateral view in evaluating the spine.²⁰ The x-ray films of the cervical vertebrae include lateral, anteroposterior, and open-mouth odontoid. The anteroposterior view should reveal the transverse processes of the C2 through T1 vertebrae. The lateral view should visualize all the vertebral bodies from the base of the occiput to the upper border of T1. The open-mouth view should visualize the lateral masses of the C1 vertebrae and the entire odontoid.

The methods of evaluating x-ray films of the spine are beyond the scope of this article, but all x-ray films should be reviewed by a radiologist or physician experienced in reading radiographs of the spine. Visualization of the cervicothoracic junction may be improved with the use of a "swimmer's view," in which the patient's arms are extended over his or her head.

Thoracic and lumbar vertebrae are evaluated with the lateral and anteroposterior views. All 12 thoracic and 5 lumbar vertebral bodies should be visualized.

Computed tomography (CT) scanning should be used in conjunction with plain x-ray films for nonvisualized portions of the spine, for any regions suspected of injury, or to better evaluate areas of fracture.^{21,22} An open-mouth view in an intubated patient is difficult to do properly and mandates a CT scan of C1 and C2 for all such patients. Most intubated patients will typically undergo CT scanning of the brain as well.

Assessment of spine tenderness or pain

Patients with tender spines require additional scrutiny before clearance can be determined. Plain x-ray films as well as CT scans demonstrate static views of the spine, which are excellent for assessing fracture. Fortunately for diagnostic purposes, the incidence of SCI without fracture is exceedingly low.⁴ However, there is a set of SCIs, particularly in the cervical vertebrae, that are not fractures but are functional in nature and consequently may not have obvious radiographic findings. These injuries often involve ligaments or the intervertebral disks, and they can cause instability of the spine. However, ligamentous injuries of the cervical vertebrae without fractures are also rare.²³

Assessment of spine tenderness requires evaluation

methods that go beyond static views. Certainly, magnetic resonance imaging will define most of these injuries; however, its cost is high and its use therefore impractical at many institutions.²⁴ Consequently, pain in the cervical vertebrae often must be evaluated using flexion-extension views.²⁵

By placing the cervical vertebrae in flexion and extension, instability from injury to the ligaments or disks will become apparent. This is an active examination, however, meaning patient participation is mandatory. The cervical collar is removed, and the patient flexes and extends the neck. The patient is instructed to stop when pain occurs or if neurologic symptoms occur. At no point should the cervical vertebrae be placed passively in flexion or extension. This examination should not be done for patients who cannot actively participate either because of intoxication or distracting pain.

Experienced personnel must supervise flexion and extension examinations, and most institutions require a physician to be present. Translation of one vertebral body over another that is greater than 3 mm is considered a positive finding. Completely linear anterior and posterior borders of the vertebral bodies are considered negative findings.

Removal of cervical immobilization devices

The literature supports the idea that many patients can have their cervical collars removed based on clinical grounds only.^{17,26} A patient can have his or her spine precautions discontinued if: (1) the results of quality x-ray films are negative for vertebral injury, (2) the patient does not display spine tenderness, and (3) the patient is "reliable," meaning that he or she is not intoxicated, does not have distracting pain or peripheral neurologic symptoms, and displays no evidence of head injury. Patients who continue to be unreliable because of mental status changes from intoxication or head injury and patients who have distracting pain should have spine clearance delayed until these issues are resolved.

The patient should be removed from the long spine board after the radiographic studies are negative for vertebral injury and the log-roll maneuver also reveals no gross evidence of injury. The cervical collar, however, must remain in place at this point. Some patients, such as those who have head injuries, may never be alert enough for a proper examination; evaluation of such patients by a neurosurgeon, or an orthopedic surgeon who is experienced in spine trauma, is recommended.

How does one manage patients who have had unreliable physical examinations for a prolonged time? There is still considerable controversy about how to deal this dilemma. However, the Trauma Practice Guidelines of the Eastern Association for the Surgery of Trauma suggest imaging the upper cervical vertebrae with plain x-ray films and CT scans, using thin-cut axial CT images through C1 and C2 to identify any potential injury.²⁷ Although this method identifies most injuries, it does not address ligamentous injury. For this reason, others believe that a flexion/extension examination under fluoroscopy should also be done.²⁸

Indications for subspecialty consultation

A neurosurgeon or orthopedic surgeon should be involved early in any case where a patient displays signs of neurologic injury or fracture. Unstable fractures of the lower cervical, thoracic, and lumbar vertebrae are often defined in terms of the three-column theory, with those columns consisting of: (1) the anterior half of the vertebral body and anterior longitudinal ligament, (2) the posterior half of the vertebral body, posterior longitudinal ligament, and facets, and (3) the spinous processes, lamina arcus vertebrae, and interspinous ligaments. Under this theory, when two of the three columns are disturbed, the spine is considered unstable.

A patient with any radiographic evidence of a spine fracture or instability on a flexion and extension series should be immediately referred to a specialist because such a patient may require early fixation or traction. Patients who have sustained blunt trauma with SCI and neuromuscular weakness or deficits are currently treated early with high-dose steroids, which mandates appropriate consultation with a specialist.

Comments

Currently, there is no defined standard for evaluating SCI based on prospective randomized research. Most studies are retrospective and support a false-negative rate of <0.1% using the three-view plain radiographs supplemented by axial CT scans for suspicious or inadequately visualized regions of the lower cervical vertebrae.^{4,17}

The number of SCIs relative to the number of blunt trauma victims is relatively small; consequently, complacency in evaluating patients with potential SCIs can lead to missed injury as a result of inadequate imaging and image-interpretation errors.²⁹ Clinicians must be compulsive in imaging the entire spine with plain x-ray films—along with the liberal use of CT scans to visualize the entire spine. Any questions or suspicions about film quality or interpretation should be referred to a radiologist or someone with experience in this type of interpretation.

The final responsibility for removing CDIs and halting spine precautions rests with the examining physician, based on clinical criteria and assessment—not purely on radiographic evaluation alone. Clinical criteria have been established to identify reliably which patients require radiographic evaluation with a high degree of confidence. When in doubt, the default action should always be radiographic evaluation and consultation with a spine specialist.

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