Spinal immobilization in trauma patients: is it really necessary?
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The acute management of potential spinal injuries in trauma patients is undergoing radical reassessment. Until recently, it was mandatory that nearly all trauma patients be immobilized with a back board, hard cervical collar, head restraints, and body strapping until the spine could be cleared radiologically. This practice is still recommended by many references. It is now clear that this policy subjects most patients to expensive, painful, and potentially harmful treatment for little, if any, benefit. Low-risk patients can be safely cleared clinically, even by individuals who are not physicians. Patients at high risk for spinal instability should be removed from the hard surface to avoid tissue ischemia. Understanding the rationale for these changes requires knowledge of mechanisms of injury, physiology, and biomechanics as they apply to spinal injuries. Curr Opin Crit Care 2002, 8:566–570 © 2002 Lippincott Williams & Wilkins, Inc.

In the early days of trauma care, patients were brought to the hospital by any means available. Eventually, ambulances began transporting many of these patients but without providing medical treatment en route. It was not until the early 1970s that emergency medical technicians were routinely trained to provide care before the patient arrived at the hospital. Initially, the care provided was not based on direct evidence of efficacy; rather, it was based on reasonable assumptions and extrapolation from in-hospital treatment. Prehospital care came to include spinal immobilization based on the logical premise that some trauma patients had spinal injuries, and some of these injuries destabilized the spinal column. Deterioration of spinal cord injuries has been attributed to movement of these destabilized injuries after the initial event and before definitive fixation [1••], but this relationship is not well substantiated in the literature. Spinal immobilization offered the promise of preventing the exacerbation of devastating injuries with apparently little downside. Soon these practices became a fundamental tenet of trauma care. Spinal immobilization, however, has never been proven to prevent secondary spinal injury [2]. This dogma is now undergoing radical reassessment, and researchers are asking whether spinal immobilization is necessary in the routine early treatment of trauma patients [3].

The basis for this heresy lies in a reevaluation of the underlying mechanism for spinal cord injury. Permanent spinal cord injury requires partial or complete transection of the cord or axonal necrosis, which requires energy deposition within the cord or its blood vessels. Because most spinal cord injuries are the result of blunt trauma, this energy transfer occurs at the point of impact. Often there are several impacts involved. For instance, a patient may strike the windshield during a rapid deceleration motor vehicle collision and subsequently strike the pavement at a high rate of speed after ejection. At the time of impact, tremendous energy is transferred to the cord. In some cases, the cord is actually partially or completely transected by bone fragments or extreme movement of the bones out of their normal alignment. It seems intuitively unlikely that subsequent movement of the spine within its normal range of motion and essentially without resistance would add significantly to the damage already done. Cases of deterioration from movement of unstable spinal injuries during extrication, transport, and initial evaluation undoubtedly do occur, but it is clear from clinical experience and the literature that

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Abbreviations
EMS emergency medical service
NEXUS National Emergency X-Radiography Utilization Study

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this is an uncommon problem. In fact, the only study that compared patients who were and were not immobilized during transport showed an increased risk of neurologic injury in the immobilized population [3].

The term unstable is used differently among different specialties and for different clinical situations. A patient may be at risk for neurologic deterioration for a variety of reasons and yet be mechanically stable. Other patients may be at risk for bony remodeling and physical deformity from long-term, unopposed gravitational force [4•] but may be both neurologically and mechanically stable in the short term. In most cases, the term unstable denotes injuries meeting the standard radiologic definition of two-column disruption [5]. This is a sensitive rather than specific definition; injuries that have two-column disruption may have no associated spinal cord injury and will not necessarily deteriorate from movement. The remainder of this report concerns injuries that have short-term biomechanical instability—that is, those that may result in increased neurologic injury if not protected during initial evaluation and treatment.

If it is assumed that spinal manipulation is not the major factor causing secondary injury, then how does one explain the clinical deterioration of spinal cord injury seen commonly in clinical practice? A variety of factors contribute to spinal cord ischemia, including vascular compromise, hypotension, hypoxia, edema, electrolyte shifts, free radical formation, and inflammatory mediators [6,7,8••]. Although it is clearly impossible to perform controlled trials comparing outcomes with and without these factors, strong evidence from animal models and clinical associations indicates that these factors are crucial determinants of final outcome.

This whole issue would be irrelevant if spinal manipulation was benign, but it is not. Documented adverse effects include pain [9,10•], restriction of breathing [11–13], tissue ischemia [14] with resulting decubiti formation [15,16], and increased intracranial pressure [17–19]. Other adverse effects include difficult nursing care, increased risk of aspiration, increased ambulance transports, treatment and evaluation delays, increased radiographs, and increased costs.

Therefore, the answer to the title question is that spinal immobilization in trauma patients is necessary sometimes; however, this answer provides no practical guidance to the practitioner. The real issue is how harm to the patient can be minimized from underimmobilization or overimmobilization. The issue can be restated as several clinically relevant questions:

(1) Which trauma patients might benefit from spinal immobilization during transport and initial evaluation?

(2) How should these patients with possible unstable injuries be immobilized?

(3) Which trauma patients require radiography in the emergency department?

(4) How can the spine be cleared in the obtunded patient?

(5) Are there special considerations for pediatric patients?

(6) Are there significant differences between patients with blunt versus penetrating injury?

### Which trauma patients might benefit from spinal immobilization during transport?

Traditional prehospital guidelines have called for the immobilization of any patient who has sustained a traumatic mechanism of injury with any potential for energy transfer to the neck. This practice is unnecessary [20]. Some emergency departments routinely perform radiographs on anyone who arrives immobilized [21], and many patients develop pain from immobilization itself [9,10•]. For every patient seen by the trauma team or ICU, tens to hundreds are evaluated and cleared by emergency physicians.

Several recent studies have demonstrated that emergency medical service (EMS) providers can use simple guidelines to determine which patients are at risk for clinically significant (ie, potentially unstable) spinal injuries and forego immobilization in the rest [20,22–24]. This practice of selective immobilization is distinguished from actual spine clearance [20]. Interestingly, these protocols for selective prehospital spinal immobilization are independent of mechanism of injury. They evaluate for neck pain, neck tenderness, neurologic deficit, and reliability of the physical examination, thereby excluding intoxicated, hemodynamically unstable, and obtunded patients. Many EMS systems also exclude multisystem trauma patients. Therefore, most patients seen by the trauma team will still arrive immobilized. These selective immobilization protocols are becoming more common and are endorsed by the National Association of EMS Physicians [25]. The new American Association of Neurological Surgeons guidelines, however, still emphasize mechanism of injury rather than the physical examination as a means to make these decisions in the prehospital setting [1••].

### How should patients with possible unstable injuries be immobilized?

Most trauma patients in the United States arrive at the hospital immobilized. Routinely, this immobilization includes a hard spine board, a cervical collar, and a means to prevent rotation of the head. Spine boards were developed as a means of extricating patients from a motor vehicle while maintaining spinal precautions; they were not intended as an immobilization device [26]. Some EMS services use padded boards or vacuum splints, which lessen but do not eliminate pain [10•,14]. Because most trauma patients are close to a hospital, and leaving
the patient on the board after extrication is efficient and
eases transfer to and from the ambulance stretcher, it is
often reasonable to leave the patient on the board. Un-
fortunately, this practice has been extrapolated to imply
that leaving the patient on the board is necessary for
immobilization, and patients remain inappropriately on
hard spine boards in the emergency department [27,28].
A hard cervical collar and a firm mattress are the standard
means of immobilizing patients with documented un-
stable injuries in the emergency department or ICU be-
fore the application of traction or definitive stabilization.

Patients who arrive at the hospital immobilized on a
spine board or vacuum splint should be evaluated im-
mediately. If continued spinal immobilization is deemed
necessary, the patient should be carefully log rolled off of
the board and placed on a firm mattress. This transfer
may be briefly delayed for initial stabilization and emer-
gency radiographs, but leaving patients on a board for
other reasons is medically inappropriate. Prehospital pa-
tients with prolonged transport times or patients being
transferred from one facility to another should not re-
main on a hard board.

**Which trauma patients require radiography
in the emergency department?**

This is one of the best-researched questions in emer-
gency medicine. The multicenter National Emergency
X-Radiography Utilization Study (NEXUS) enrolled
34,069 patients [29]. The investigators determined that
only patients with midline neck tenderness, focal neu-
rologic deficit, altered mental status, intoxication, or
painful distracting injury require radiographs to exclude
spinal injury. Neck pain was not a criterion nor was a
mechanism of injury. These criteria were 99.6% sensitive
for clinically significant (ie, potentially unstable) injuries.
A large trial in Canada derived a different set of criteria,
which appear to be equally sensitive but more complica-
ted to use [30••]. These criteria are currently under-
going validation.

The NEXUS criteria are very similar to the prehospital
criteria mentioned. Therefore, as more EMS systems use
selective spinal immobilization protocols, more of the
patients who arrive immobilized will indeed require ra-
diographs. For trauma and critical care specialists, the
spectrum bias of their patient population will less com-
monly allow clearance without radiographs. However,
these criteria can be applied to any patient who has a
reliable clinical examination. Although many clinicians
automatically consider any fracture to be a distracting
injury affecting examination reliability, others are more
comfortable making case-by-case decisions.

**How is the spine cleared in the case of the
obtunded patient?**

There seem to be two major schools of thought on this
issue. One group obtains a definitive study to rule out
ligamentous injury in all obtunded trauma patients, re-
gardless of whether the results of their cervical spine
radiographs and computed tomography (CT) scans are
negative [31–33]. This definitive study may be a mag-
netic resonance image or dynamic fluoroscopic
flexion/extension studies. Usually, this study is deferred
for as long as 1 week until the patient improves enough
to be clinically evaluated, or dies. During this period,
the patient is maintained with routine spinal precautions.
Unfortunately, these precautions significantly complicate
nursing care in the ICU and expose the patient to all
of the aforementioned risks. The other group counts on
the rarity of unstable ligamentous injury in the setting of
completely normal radiographs. If the results of the ini-
tial spine work-up, including radiographs and possibly
CT, are normal, spinal precautions are discontinued
[34,35]. The current recommendations of the American
Association of Neurological Surgeons encompass all of
these options [36••].

**Are there special considerations for
pediatric patients?**

Because most young children do not tolerate immobili-
mation well, it is ideal to avoid it whenever possible. Chi-
dren tend to injure their upper spine and often die be-
fore transport. Fortunately, pediatric spinal injuries are
rare, and many of the injuries that do occur do not in-
volve an underlying unstable spinal injury [37,38].
Therefore, if pediatric trauma patients were never im-
mobilized, an unstable injury would rarely be missed.
However, considering the potential tragic outcome of an
unrecognized injury, the goal should still be to identify
patients at high risk for unstable injury and immobilize
them appropriately.

Given the lower numbers of pediatric spine injuries, it is
much harder to conduct powerful research. There is in-
sufficient evidence to recommend applying selective im-
mobilization criteria to young children in the prehospital
setting. However, the criteria are commonly applied, and
the practice seems reasonable in some cases, particularly
in children old enough to converse. There is evidence to
suggest that children who can communicate adequately
may be evaluated for clinical clearance in the emergency
department in the same manner as adults [39••,40••].
Once the decision is made to immobilize, anatomic dif-
fferences must be considered to achieve a neutral posi-
tion, particularly the proportionally larger head and
prominent occiput.

**Are there significant differences between
patients with blunt versus penetrating
mechanisms of injury?**

Patients with certain kinds of penetrating injuries are
extremely unlikely to have biomechanical unstable cer-
vical or thoracic spines. For example, patients who are
shot in the head do not absorb enough energy to break
the spine. Kaups and Davis [41] looked at 215 patients
with gunshot wounds to the head. The only three patients with spinal injury had direct wounds to the spinal column with entrance or exit wounds suggesting transcervical trajectory. There were no indirect spinal injuries. Newtonian physics requires that the energy imparted by a bullet decelerated to a stop by tissue is equal to that of the recoil of the pistol. If the recoil from a weapon placed against the side of a head does not deposit enough energy to break the neck, then being shot in the head should not, either.

The situation is perhaps different for patients who have direct penetrating injuries to the spine. Spinal cord injury from penetrating trauma usually occurs at the time of injury from direct cord damage and not from the creation of a biomechanically unstable lesion. However, firearms can generate enough energy to disrupt the classic two columns, and unstable injuries have been reported in a small percentage of patients [42–44].

In the absence of controlled studies, a logical approach is to immobilize any victim of penetrating firearm trauma who has a focal neurologic deficit or altered mental status in whom the trajectory likely traverses the spinal column, provided that immobilization does not interfere with management of the airway or bleeding vessels.

Conclusions
Like much of medicine, spinal immobilization is a concept that became the standard of care based on common sense rather than research. There are convincing biomechanical arguments and some preliminary research that suggest that spinal immobilization may not be necessary, even in many trauma patients with unstable injuries. Until further research clarifies which injuries, if any, truly benefit from immobilization, immobilization will remain the standard practice. The clinician’s goal should be to apply it only to those patients predicted to be at risk for unstable injury and to do as little harm from immobilization as possible.

References and recommended reading
Papers of particular interest, published within the annual period of review, have been highlighted as:
• Of special interest
** Of outstanding interest


29 Hoffman JR, Mower WR, Wolfson AB, et al.: Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma: National

30 Stiell I, Wells GA, Vandemheen KL, et al.: The Canadian c-spine rule for radiography in alert and stable trauma patients. JAMA 2001, 286:1841–1848. This study is the Canadian answer to the NEXUS trial. This is actually just the derivation of a clinical decision rule for when to obtain c-spine radiographs in asymptomatic trauma patients but includes almost 9000 patients. Prospective validation of the rule is pending.


This chapter of the Neurosurgery supplement reviews the evaluation of the spine in the obtunded trauma patient. Based on the available evidence, the authors support very diverse practices.


This chapter of the Neurosurgery guidelines reviews all of the critical issues in the early assessment and management of pediatric spinal injury. Most interestingly, they support the use of clinical rather than radiographic assessment of the spine in selected pediatric patients.

40 Viccellio P, Simon H, Pressman BD, et al.: A prospective multicenter study of cervical spine injury in children. Pediatrics [serial online] 2001, 108:E20. This study presents the pediatric subgroup data from the NEXUS trial. Because spinal injury is rare in young children, the numbers are small, but these are the best data available on clinical spine clearance in pediatric patients.


