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SPINAL IMMOBILIZATION

TIME FOR A CHANGE

>> BY JIM MORRISSEY, MA, EMT P

Prehospital spinal immobilization has long been held as the standard of care for victims of blunt or penetrating trauma who have experienced a mechanism of injury (MOI) forceful enough to possibly damage the spinal column. The majority of EMS textbooks stress that any significant MOI, regardless of signs and symptoms of spine injury, requires full-body immobilization, which is typically defined as a cervical collar being applied and the patient being secured to a backboard with head stabilizers in place.

This approach to patient immobilization has been accepted and implemented as the standard of care for decades with little scientific evidence justifying the practice.¹⁻³ In addition, scant data shows that immobilization in the field has a positive effect on neurological outcomes in patients with blunt or penetrating trauma.^{1,4-6} In fact, several studies and articles show that spine immobilization may cause more harm than good in a select sub-set of trauma patients.⁵⁻⁷

Many experts question the current practice of prehospital spinal immobilization.^{1,2,4-15} There are now some guidelines, textbooks and an increasing number of EMS agencies that support a progressive, evidence-based approach in an effort to lessen unnecessary spinal immobilizations in the field.

It's problematic to use MOI alone as the key indicator for prehospital spinal immobilization. In addition, the harmful sequelae and potential dangers of spine immobilization need to be considered in any field protocol. We need to examine appropriate spine injury assessment guidelines and algorithms that allow for the selective immobilization of injured patients.

We also should review immobilization devices and techniques that are more appropriate for patients who *do* require immobilization, or better termed, spinal motion restriction (SMR), by EMS providers.

OUTDATED INDICATORS?

It typically takes several years for EMS textbooks to catch up with new evidence and then additional time for the EMS instructional community to modify curricula and change current practice. For example, definitions of mechanisms that require spinal immobilization found in most EMS textbooks are outdated and problematic. Such indicators for potential spine injury as fall, damage to the vehicle, injury above the clavicle and mechanism of injury involving motion, are not particularly helpful when determining the best course of action in the field.

Especially troubling has been the lack of emphasis on the assessment of the patient before making a decision about immobilization. Historically, more emphasis has been placed on what happened to the vehicle or the best guess on how far someone may have fallen, instead of what actually happened to the person.

It isn't the fall that causes injury; it's the sudden stop at the end. The more sudden the stop, the more likely an injury results, especially if the kinetic energy was transmitted to the head and/or neck.

The physical condition of the patient must also be considered. A young, athletic person is able to withstand more forces than an elderly patient. So the spectrum of potential injuries is best determined through a detailed history and physical exam.

Vehicle damage has long been considered a strong indicator of potential spine injury, yet improvements in vehicular design and construction should change the way we look at vehicle damage. Vehicle technology and passenger protection is far superior to what it has been, particularly since the 70's when EMS textbooks began advocating back boarding of patients in vehicles with significant damage.

Vehicle damage zones are now inherently built into newer

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There are many situations (hostile environment, life threatening injuries) where spinal immobilization may be detrimental to good patient care. This training scenario emphasizes rapid extrication.

vehicles, designed to absorb and dissipate the kinetic energy of a collision, and keep the passenger cabin relatively isolated and protected.¹⁶ An experienced paramedic once said, “The cake box might be crumpled, but the cake can be fine.”

Some textbooks accurately address this issue. Even as far back as 1990, the American Academy of Orthopaedic Surgeons addressed emergency medical responders in an extended-care environment, stating, “Patients with a positive mechanism of injury, without signs and symptoms, and with a normal pain response may be treated without full spine immobilization, if approved by your medical control physician.”¹⁷

Emergency medical personnel who work in extended-care, tactical, combat and wilderness environments have long realized the need to safely and accurately assess and clear patients regarding spinal injuries.^{18,19}

New guidelines from Prehospital Trauma Life Support and the National Association of EMS Physicians have diminished the emphasis on immobilizing

victims of penetrating trauma without neurologic deficits.²⁰

In the setting of drowning, the 2010 evidence-based guidelines from the American Heart Association state that “Routine c-spine immobilization is a Class III (potentially harmful) unless clear trauma is evident in the history or exam, because it may unnecessarily delay or impede ventilations.”²¹



PHOTO ART VANDALAY

Assessment is still the key to determining the need for spinal immobilization.

PRECAUTIONARY IMMOBILIZATION

It isn't surprising that the term and practice of “precautionary immobilization” has developed. It's estimated that at least five million patients are immobilized in the prehospital environment in the U.S. each year. Most have no complaints of neck or back pain or other evidence of spine injury.^{3,11,12} (See Photo 2.)

EMS personnel historically have neither been given the tools nor the authority to make informed decisions about objectively determining the need for prehospital spinal immobilization. This may be because the emergency medical community thought immobilization was always safe, conservative and always in the best interest of the patient. However, evidence now shows that, in some cases, spinal immobilization may not be in the patient's best interest.^{1-3,7,8,10-13}

Some prehospital care providers will admit that they often immobilize patients without evidence of spine injury because they want to avoid being questioned on arrival at the emergency department (ED). This dynamic can (and must) change with education and outreach.

BACKBOARD-BASED IMMOBILIZATION

In addition to patient discomfort and anxiety associated with backboard-based immobilization, there are several potentially significant consequences. Standard immobilization requires the patient's body to conform to a flat, hard surface. In addition, EMS secures a cervical collar around the patient's neck and uses tape to secure the patient's head to the board.

This practice often increases patient anxiety and has the potential to aggravate underlying injuries. Standard spinal immobilization techniques can also take away the patient's ability to effectively protect their own airway thus significantly increasing the risk of aspiration.^{3-6,11,13}

Patient vomiting, bleeding, airway drainage and swelling are common problems associated with trauma patients. Even with one EMS provider dedicated to the management of the airway and patient suction, it cannot be assumed that a suction catheter can handle the job when significant bleeding and/or vomiting is presented.

The continued spinal stability of a patient who is turned on their side to facilitate airway drainage and control is also questionable. Patients typically experience a significant

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Patients with penetrating trauma (ex., gunshots and stabbings) to the head and torso usually do not benefit from spine immobilization.

shift in body weight and distribution, causing more movement to the spine than the immobilization process was intended to prevent.

In a comprehensive review published in *Prehospital and Disaster Medicine*, healthy volunteers who were immobilized on a backboard were found to be “significantly more likely to complain of pain when compared with immobilization on a vacuum mattress.” Adverse effects of backboard-based immobilization documented in this study include increased ventilatory effort, pain and discomfort.

In addition to pressure injury, the backboard may also be the cause of pain—even in otherwise healthy volunteers. The resultant posterior surface/back pain of immobilized patients has been documented to result in unnecessary radiographs and potential clinical ambiguity regarding the cause of the pain.^{3,22} There’s an increased cost associated with some of these complications.

It has been documented that supine patient immobilization results in a 15–20% reduction in respiratory capacity, and that respiratory effectiveness is markedly reduced by the strapping systems typically used.^{3,9,13} Patients are often either strapped securely, thus having diminished respiratory capacity, or loosely secured, facilitating easier breathing. Neither scenario is ideal.

The challenge is exacerbated in obese patients, the elderly and patients with such underlying diseases as congestive heart failure, COPD, asthma and pneumonia.

Done properly, immobilization in the field takes time and multiple personnel. Time delay to the ED or trauma center arrival has been cited as a significant problem for critical trauma victims. Several studies have looked at the risk vs. benefit of prehospital immobilization, with several authors and researchers questioning the value of current practices.^{1,2,7,8,11,15}

Studies have also shown limited or no benefit of prehospital immobilization of penetrating trauma patients. (See photos on pages 32 and 33.) Unnecessary immobilization of this subset of trauma patients can result in prolonged on-scene time and delayed transport to definitive care, which may increase morbidity and mortality.^{4-6,14,18,23-25}

Several studies show that cervical collars by themselves aren't without risk or significant consequences.^{4,26-28} One study concludes that cervical collars frequently increase intracranial pressure and may be particularly harmful if used on head-injured patients.²⁶

Another researcher observed that cervical collars "can result in abnormal distraction within the upper cervical spine in the presence of severe injury."²⁸ In addition, cervical collars hide areas of the head and neck, resulting in the increased possibility of missing injuries or evolving problems, such as swelling, hematoma and tracheal deviation.^{27,28}

In addition, the longer a patient is immobilized, the more likely that cutaneous pressure ulcers will develop, most notably in the occipital, sacral or heel areas.^{9,12,22,29,30} This is especially true in elderly, unconscious and neurologically impaired patients. This problem may be significantly reduced with padding or use of a vacuum mattress. Unfortunately, the vast majority of the patients who are immobilized don't get padding in voids or areas of significant body weight/pressure or a vacuum mattress that distributes beads/padding in voids and uneven body surface areas.

THE PENETRATING TRAUMA PATIENT

As referenced earlier, there is a growing body of evidence that suggests penetrating trauma victims shouldn't be routinely immobilized. Immobilization has been associated with higher mortality in patients with penetrating trauma.^{4-6,14,23-25}

Independent studies show that whether the penetrating trauma is to the head, neck or torso, immobilization is unnecessary, interferes



Tactical teams often use compact, flexible extraction devices.

PHOTO COURTESY JIM MORRISSEY/JOSH KENNEDY

with and delays emergent care, and should be seriously reconsidered as the standard of care.^{4-6,14,23}

A *Journal of Trauma* article concluded, “Indirect spinal injury does not occur in patients with gunshot wounds to the head.” The authors state, “Protocols mandating cervical spine immobilization after a gunshot wound to the head are unnecessary and may complicate airway management.”¹⁴

Another retrospective study showed similar concerns about the use of a cervical collar with patients who have penetrating injuries to the neck. This study suggests that avoiding the collar should be the rule, and that a provider who chooses to apply a cervical collar should have good justification. The authors also suggest that frequent examination of the underlying structures and tissue is warranted if a cervical collar is used.⁴

A comprehensive retrospective analysis of gunshot injuries to the torso found that immobilization was of little or no benefit, even if an unstable spine fracture was present. The authors argue that airway management, including intubation, is far more complicated and problematic with prehospital spinal immobilization in place.^{5,6}

In fact, failed airway management was reported to be the second-leading error preceding death of trauma patients, accounting for 16% of mortality in one study. This study also highlights the potential delay to definitive surgical treatment and the lack of neurologic improvement after gunshot injury to the spinal cord, suggesting that prehospital spinal immobilization is unjustified.^{5,6}

PROPER SPINE INJURY ASSESSMENT

For many trauma patients, a vetted field assessment criterion that focuses on the assessment of the patient rather than the mechanism of injury would obviate unwarranted immobilization.^{3,11,31}

Many emergency medicine specialists believe an accurate, reliable, simple-to-perform spinal injury assessment could reduce spine immobilizations drastically. Thankfully, there is a trend in this direction across the nation.

The idea of “clearing” a patient of spinal injury in the field has been, and continues to be debated. However, there are prehospital spine assessment protocols that safely and accurately allow EMTs and paramedics to omit prehospital spinal immobilization in certain patients.

Some EMS experts prefer the term “selective immobilization” to “clearing” the c-spine, but the end result is the same. The end result is the reduction of the incidence of unwarranted spinal immobilizations.

For example, the Maine spine injury assessment guidelines, developed by Peter Goth, MD, in the 1990s, have been shown to be accurate and safe.^{10,31,32} Several states and EMS systems around the nation use this, or a similar protocol, to help decrease the number of trauma patients being subjected to prehospital spinal immobilization.

The origin of this type of spinal assessment was initially intended to help ED physicians clinically decide if they can safely clear patients from prehospital spinal immobilization and reduce or eliminate unnecessary radiographic studies. It has been shown that the proper clinical exam and history is more accurate at predicting spine injuries than X-ray review.^{10,32-35}

The spine injury assessment guidelines that have been adopted

by multiple prehospital systems are based on the Canadian C-spine rule and the National Emergency X-Radiography Utilization Study (NEXUS) low-risk criteria. Each has similar parameters, requiring that the patient be awake, alert, conversant and without significant distracting injury or intoxication.

In addition, the guidelines further state that the physical exam should reveal no pain or tenderness to the posterior neck and back and the neurologic exam must find normal motor and sensory function in the extremities.^{10,18,31,33-35}

Studies show that prehospital care providers can safely apply spine injury assessment criteria and not miss any clinically significant spine injuries.^{10,31,32} Although these guidelines are



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Some patients, such as pediatric patients, require special spinal immobilization consideration.



PHOTO CHRIS SWABB

Children have been immobilized acceptably in specialized spinal devices for decades.

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available, training and practice is needed to become proficient at using these criteria.

Alameda County (Calif.) EMS has revised its spine injury assessment protocol to accurately reflect the current literature and research. (See Figure 1, p. 38). Its goals in 2012 were to reduce unnecessary immobilization, and use treatment modalities in the best interest of and provide the most comfort to the patient. In some cases, this meant forgoing prehospital spinal immobilization to expedite transport to a trauma center.



PHOTO A.J. HEIGHTMAN

A vacuum splint can be used as a highly moldable and comfortable cervical immobilization device.

However, long-established norms are hard to break, and extensive training was required to make this new policy successful. EMS schools, fire departments and other EMS providers, as well as emergency department staff, needed to be exposed to the literature and trained in the new protocol.

Initial training and outreach has been well received and the early indicators have shown a significant reduction in spine immobilizations. The end result is:

- >> A better understanding of the need for expeditious care under specific circumstances, in particular, the need to move rapidly when penetrating trauma is present;
- >> All involved are empowered to break the paradigm of “board them all” as a result of understanding the importance of proper spinal/neurological assessment and assessment parameters that allow crews to assess for serious spinal indications and perform selective immobilization. We did the same process decades ago when we adopted rapid removal techniques for



PHOTO ED DOBRK

Patients can be immobilized safely and comfortably via a combination of a backboard or other flexible or scoop-type stretcher, such as shown here with a Hartwell Combi-Carrier/vacuum mattress combination.

patients in lieu of spending precious minutes placing splints and half backboards on critical patients. Little or no untoward results occurred with that change in procedure;

- >> More attention to patient comfort and pain instead of routine placement of trauma patients on a hard, uncomfortable platform that often put them in anatomically-incorrect positions for extended time periods, made patients unnecessarily claustrophobic lying supine and immobile and exacerbation of respiratory distress in patients due to the supine position, strap placement, and existing conditions such as CHF, COPD or morbid obesity; and
- >> The ability to deploy and maximize the usage of alternative immobilization and transfer devices and stretchers such as vacuum mattresses, scoop or CombiCarriers and flexible stretchers such as Ferno and SKED stretchers and others that feature lateral patient support slats and multiple handles for convenient movement and transfer

of patients. Many of these devices are better suited to patient movement in tight spaces and crew body mechanics when carrying and transferring patients down stairways and other difficult environments.

Of course, crews have to take special caution when dealing with and managing high-risk patients, including pediatric patients, the elderly and those with such degenerative bone disorders as osteoporosis. Field personnel need to be conservative while evaluating these patients and should provide spinal motion restriction when in doubt.^{33,34}

UNCONVENTIONAL OPTIONS

Even with appropriate application of spine injury assessment guidelines, some patients still require some degree of prehospital spinal motion restriction. Vacuum mattresses and other break-away and flexible stretchers have been used successfully throughout Europe for years. They score well in several critical areas, including patient comfort, secure immobilization, insulation, lack of pressure



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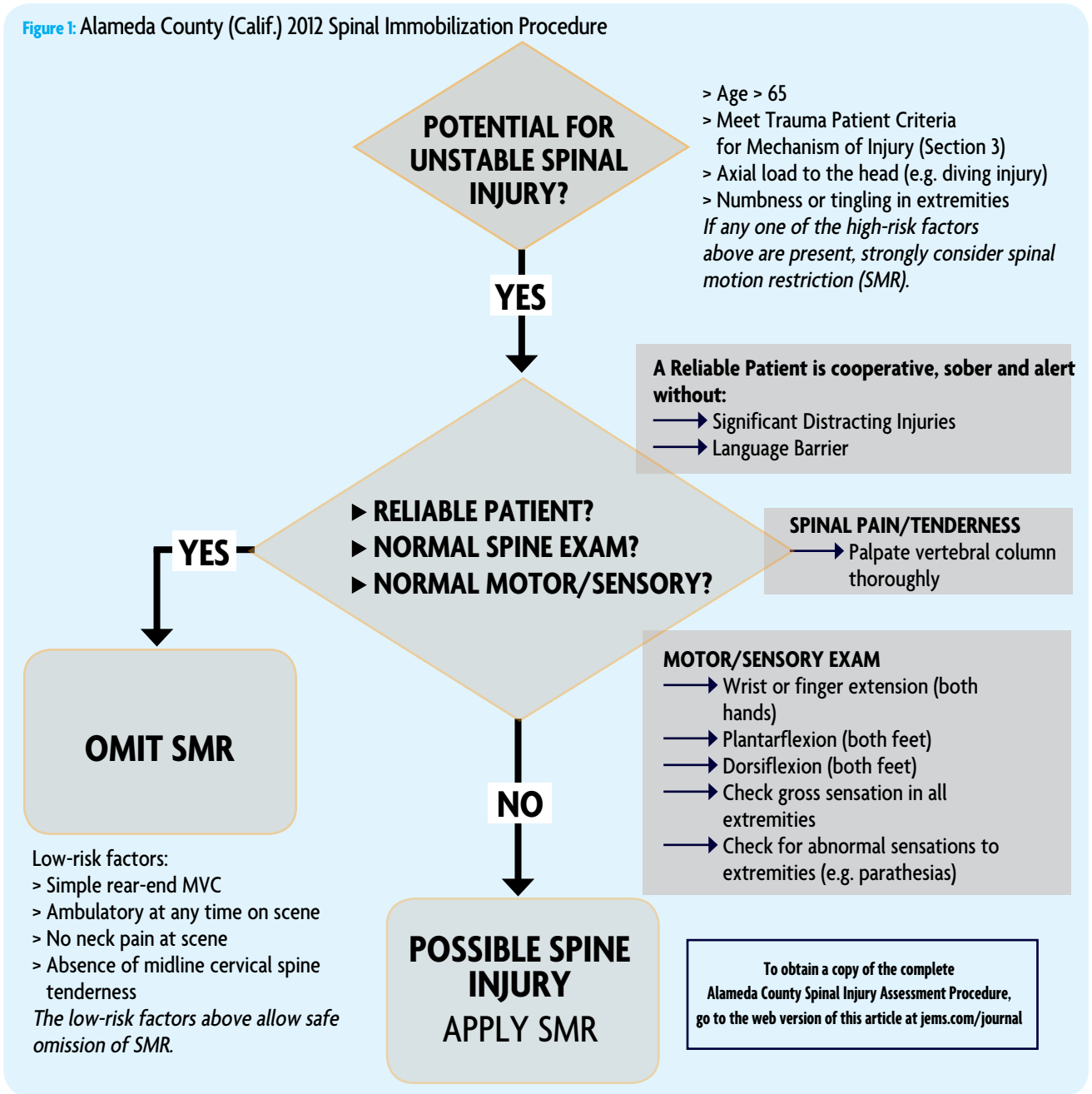
This patient is securely immobilized in a Ferno Germa Easyfix vacuum mattress – stretcher.



PHOTO A.J. HEIGHTMAN

Vacuum mattresses and stretchers pad voids and distribute a patient's weight evenly.

Figure 1: Alameda County (Calif.) 2012 Spinal Immobilization Procedure



sore development and, in the case of some vacuum device configurations, allow crews to utilize them without a cervical collar.^{12,29,30}

When considering adding vacuum mattresses, vacuum stretchers or other immobilization devices to your arsenal, keep in mind that they don't require more effort or training than using backboards. Vacuum mattresses can also effectively pad voids, distribute weight evenly and immobilize patients on their side because the device can be "molded" around the patient to best package them safely. (See photos on page 36.)

However, keep in mind that backboards

still have a place, especially to restrain or slide a patient out of an extrication mess. There is also nothing that precludes you from utilizing a combination of devices such as a backboard or scoop-type stretcher to remove a patient and transfer them to a more moldable or comfortable secure surface such as a vacuum mattresses. Many systems use this combination or deploy vacuum mattresses in conjunction with flexible stretchers. (See photo, top of page 36.)

Another emerging school of thought questions the need for traditional prehospital spinal immobilization at all—even for

patients who have positive evidence of a spinal column or spinal cord injury. One group of researchers who compared various extrication tools and methods found that allowing a patient to self-extricate from a vehicle with a cervical collar alone caused less movement of the spine than the use of cervical collar, KED extrication device and standard extrication techniques.³⁶ This triggers a series of questions that are beyond the scope of this article. Groups such as the National Association of EMS Physicians and the U.S. Metropolitan Municipalities Medical Directors and Global Affiliates Consortium

are carefully discussing these options and revisions to our traditional approaches to neck and spine immobilization

CONCLUSION

It's appropriate for emergency personnel to immobilize certain trauma patients. However, many other trauma patients are unnecessarily immobilized by EMS. Spinal immobilization isn't always a benign intervention. It can result in increased scene time, delay of delivery to definitive care, problematic airway management, increased patient pain or dyspnea, and unnecessary radiographic testing.

Many trauma patients can be safely and accurately assessed and treated without immobilization if they meet all criteria in prehospital spinal assessment guidelines. Extensive initial training and ongoing review is necessary for an effective selective immobilization protocol.

Science, research and multiple validated articles have changed the way EMS practices. If good patient care is the goal, it's time that prehospital spinal immobilization be critically examined. **JEMS**

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REFERENCES

1. Hauswald M, Ong G, Tandberg D, et al. Out-of-hospital spinal immobilization: Its effect on neurologic injury. *Acad Emerg Med*. 1998;5(3):214-219.
2. Baez AA, Schiebel N. Evidence-based emergency medicine/systematic review abstract. Is routine spinal immobilization an effective intervention for trauma patients? *Ann Emerg Med*. 2006;47(1):110-112.
3. Kwan I, Bunn F. Effects of prehospital spinal immobilization: a systematic review of randomized trials on healthy subjects. *Prehosp Disaster Med*. 2005;20(1):47-53.
4. Barkana Y, Stein M, Scope A, et al. Prehospital

stabilization of the cervical spine for penetrating injuries of the neck: Is it necessary? *Injury*. 2000;31(5):305-309.

5. Haut ER, Kalish BT, Efron DT, et al. Spine immobilization in penetrating trauma: More harm than good? *J Trauma*. 2010;68(1):115-120; discussion 120-121.
6. Brown JB, Bankey PE, Sangosanya AT, et al. Prehospital spinal immobilization does not appear to be beneficial and may complicate care following gunshot injury to the torso. *J Trauma*. 2009;67(4):774-778.
7. Smith JP, Bodai BI, Hill AS, et al. Prehospital stabilization of critically injured patients: A failed concept. *J Trauma*. 1985;25(1):65-70.
8. Seamon MJ, Fisher CA, Gaughan J, et al. Prehospital procedures before emergency department thoracotomy: 'Scoop and run' saves lives. *J Trauma*. 2007;63(1):113-120.
9. Chan D, Goldberg R, Tascone A, et al. The effect of spinal immobilization on healthy volunteers. *Ann Emerg Med*. 1994;23(1):48-51.
10. Domeier RM, Frederiksen SM, Welch K. Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria. *Ann Emerg Med*. 2005;46(2):123-131.
11. Kwan I, Burns F. Spinal immobilization for trauma patients (Cochrane Review). *Cochrane Review*; 2009; 11 <http://summaries.cochrane.org/CD002803/spinal-immobilisation-for-trauma-patients>.
12. McHugh TP, Taylor JP. Unnecessary out-of-hospital use of full spinal immobilization. *Acad Emerg Med*. 1998;5(3):278-280.
13. Totten VY, Sugarman DB. Respiratory effects of spinal immobilization. *Prehosp Emerg Care*. 1999;3(4):347-352.
14. Kaups KL, Davis JW. Patients with gunshot wounds to the head do not require cervical spine immobilization and evaluation. *J Trauma*. 1998;44(5):865-867.
15. Hauswald M. A re-conceptualisation of acute spinal care. *Emerg Med J*. Sept. 8, 2012. [Epub ahead of print].
16. Centers for Disease Control and Prevention (Sept. 6, 2012). Guidelines for Field Triage of Injured Patients. 2011; Retrieved from www.cdc.gov/FieldTriage. Accessed Sept. 24, 2012, 2012.
17. Worsing R. *Basic Rescue and Emergency Care. First Edition*. Ed: American Academy of Orthopaedic Surgeons, Park Ridge, IL; 1990; 253.
18. Goth P. Spine Injury. Clinical Criteria for Assessment and Management. Augusta, ME: Medical Care Development Publishing; 1994.
19. Morrissey J. *Field Guide of Wilderness Medicine and Rescue. Third Edition* Ed: Wilderness Medical Associates, Portland, ME; 2000; 30-33.
20. Stuke LE, Pons PT, Guy JS, et al. Prehospital spine immobilization for penetrating trauma: Review and recommendations from the Prehospital Trauma

Life Support Executive Committee. *J Trauma*. 2011;71(3):763-769; discussion 769-770.

21. Berg RA, Hemphill R, Abella BS, et al. Part 5: Adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2010;122(18 Suppl 3):S685-S705.
22. March JA, Ausband SC, Brown LH. Changes in physical examination caused by use of spinal immobilization. *Prehosp Emerg Care*. 2002;6(4):421-424.
23. Kennedy FR, Gonzalez P, Beitler A, et al. Incidence of cervical spine injury in patients with gunshot wounds to the head. *South Med J*. 1994;87(6):621-623.
24. Chong CL, Ware DN, Harris JH, Jr. Is cervical spine imaging indicated in gunshot wounds to the cranium? *J Trauma*. 1998;44(3):501-502.
25. Arishita GI, Vayer JS, Bellamy RF. Cervical spine immobilization of penetrating neck wounds in a hostile environment. *J Trauma*. 1989;29(3):332-337.
26. Davies G, Deakin C, Wilson A. The effect of a rigid collar on intracranial pressure. *Injury*. 1996;27(9):647-649.
27. Kolb JC, Summers RL, Galli RL. Cervical collar-induced changes in intracranial pressure. *Am J Emerg Med*. 1999;17(2):135-137.
28. Ben-Galim P, Dreiangel N, Mattox KL, et al. Extrinsic collars can result in abnormal separation between vertebrae in the presence of a dissociative injury. *J Trauma*. 2010;69(2):447-450.
29. Cordell WH, Hollingsworth JC, Olinger ML, et al. Pain and tissue-interface pressures during spine-board immobilization. *Ann Emerg Med*. 1995;26(1):31-36.
30. Luscombe MD, Williams JL. Comparison of a long spinal board and vacuum mattress for spinal immobilization. *Emerg Med J*. 2003;20(5):476-478.
31. Muhr MD, Seabrook DL, Wittwer LK. Paramedic use of a spinal injury clearance algorithm reduces spinal immobilization in the out-of-hospital setting. *Prehosp Emerg Care*. 1999;3(1):1-6.
32. Domeier RM, Evans RW, Swor RA, et al. The reliability of prehospital clinical evaluation for potential spinal injury is not affected by the mechanism of injury. *Prehosp Emerg Care*. 1999;3(4):332-337.
33. Stroth G, Braude D. Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for selective immobilization. *Ann Emerg Med*. 2001;37(6):609-615.
34. Barry TB, McNamara RM. Clinical decision rules and cervical spine injury in an elderly patient: a word of caution. *J Emerg Med*. 2005;29(4):433-436.
35. Burton JH, Dunn MG, Harmon NR, et al. A statewide, prehospital emergency medical service selective patient spine immobilization protocol. *J Trauma*. 2006;61(1):161-167.
36. Shafer JS, Naunheim RS. Cervical spine motion during extrication: a pilot study. *West J Emerg Med*. 2009;10(2):74-78.