WILDERNESS MEDICAL SOCIETY PRACTICE GUIDELINES

Wilderness Medical Society Practice Guidelines for Spine Immobilization in the Austere Environment: 2014 Update

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In an effort to produce best practice guidelines for spine immobilization in the austere environment, the Wilderness Medical Society convened an expert panel charged with the development of evidence-based guidelines for management of the injured or potentially injured spine in an austere (dangerous or compromised) environment. Recommendations are made regarding several parameters related to spinal immobilization. These recommendations are graded on the basis of the quality of supporting evidence and balance between the benefits and risks or burdens for each parameter according to the methodology stipulated by the American College of Chest Physicians. A treatment algorithm based on the guidelines is presented. This is an updated version of original WMS Practice Guidelines for Spine Immobilization in the Austere Environment published in *Wilderness & Environmental Medicine* 2013;24(3):241–252.

Key words: spinal injury, spinal trauma, spinal immobilization, cervical spine injury, cervical spine immobilization, cervical spine clearance

Introduction

Techniques for immobilization and extrication of the patient with a real or potential spine injury have been implemented for decades. These techniques use practical but not systematic approaches driven by a well-intentioned aversion to inflicting further serious injury. Furthermore, there is little evidence to support the effectiveness or necessity of these techniques. Prehospital care of the spine may represent one of the more illustrative examples of clinical medicine being driven more by medicolegal implications than sound clinical or scientific evidence. Although the high cost (in terms of both dollars and resources) of defensive medicine in this regard may or may not be justified in the civilized environment, in the austere (dangerous or compromised) environment any decision to immobilize a spine is directly associated with the potential for further injury to the patient as well as rescuers. When an injured, or potentially injured, patient is located in a compromised environment, rescuers will often literally be risking their lives to both avoid further injury to the patient and effect a safe extrication. Under these circumstances, the need for sound evidence in clinical decision making is paramount.

In an effort to develop proper guidelines for spinal immobilization in the austere environment, based on best existing evidence, an expert panel was convened to develop evidence-based guidelines.

Methods

A panel with experts in the field was convened at the Wilderness Medical Society (WMS) annual meeting in Snowmass, CO, in July 2011. Members were selected from multiple professional backgrounds on the basis of clinical interest or research experience. The panel includes 2 orthopaedic surgeons, 2 experienced academic emergency medical technicians (EMTs; 1 military and 1 civilian), 1 emergency physician, and 1 family practitioner with sports medicine fellowship training. Relevant articles were identified through the PUBMED and

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Cochrane Collaboration databases using key word searches with the appropriate terms corresponding to each topic. Peer-reviewed studies related to spine immobilization including randomized controlled trials, observational studies, and case series were reviewed, and the level of evidence supporting the conclusions was assessed. Abstract-only studies were not included. Conclusions from review articles were not considered in the formulation of recommendations but are cited in an effort to provide context. When no relevant studies were identified, the expert panel recommendation was based on risk vs benefit perceptions derived from patient care experience. The panel used a consensus approach to develop recommendations regarding management of spinal injuries in the wilderness. These recommendations have been graded on the basis of clinical strength as outlined by the American College of Chest Physicians (see the online Supplementary ACCP Table 1).[1] This is an updated version of the original WMS Practice Guidelines for Spine Immobilization in an Austere Environment published in *Wilderness & Environmental Medicine* 2013;24(3):241–252.

SCOPE OF THE PROBLEM

The incidence of spinal cord injury (SCI) in the United States is estimated at 40 to 50 cases per million people per year, representing 3% of hospital trauma admissions.[2] A Norwegian epidemiologic study[3] revealed an incidence of cervical spine fractures of 11.8/100,000 per year. Of these injuries, 60% were secondary to falls, and 21% were secondary to motor vehicle collisions. The incidence of open surgery for these injuries was 3.1/100,000 per year.

Two to five percent of patients with SCI will demonstrate neurologic deterioration, regardless of the effectiveness of prehospital care, based on the pathophysiology of the injury itself (progressive neurologic ischemia, spinal cord edema, etc).[4,5]

Authors have noted an improvement in neurologic status of SCI patients arriving in emergency departments during the past 30 years. During the 1970s, 55% of patients referred to SCI centers arrived with complete neurologic lesions, whereas in the 1980s that number decreased to 39%.[6] This improvement in neurologic status has been attributed to emergency medical services (EMS) initiated in the early 1970s. However, there is no evidence to support the belief that this improvement has anything to do with EMS protocols. Certainly, improvements in automobile safety and design, along with compulsory seat belt use laws, are at least partially responsible for these observations. Review of data from the National Automotive Sampling System data files between 1995 and 2001 revealed 8412 cases of cervical spine injury.[7] Approximately half (44.7%) were unrestrained occupants, and the remainder consisted of belted only (38.2%), airbag only (8.8%), and both (8.4%) restraint systems.

It is important to interject some a priori clarity to the publication of these guidelines. Many articles have been repeatedly quoted in the literature as offering case evidence of neurologic deterioration in the presence of SCI secondary to inadequate prehospital immobilization.[8–14] Careful review of these cases, however, reveals that virtually all represent missed or late diagnoses after hospital admission, or deterioration that occurred while under treatment for a known diagnosis.

The focus of these guidelines is to present an evidence-based approach to prehospital care that minimizes the possibility of neurologic deterioration in the presence of an existing or potential SCI from the time of extrication to arrival at a medical facility.

Spinal immobilization itself is not a benign procedure. In addition to the risk of further injury to the patient as a consequence of increasing the danger of rescue, spinal immobilization is associated with documented risks and rather extreme discomfort. Although the expert panel was unable to identify a single well-documented case in the literature of prehospital neurologic deterioration as a direct consequence of improper or inadequate immobilization, many cases have documented severe morbidity, and even mortality, secondary to immobilization itself.[2,15–26]

For the purpose of developing proper guidelines for spinal immobilization in a dangerous environment, it is important to recognize and attempt to differentiate 5 types of spinal injury scenarios: 1) an uninjured spine; 2) a stable spine injury without existing or potential neurologic compromise; 3) an unstable, or potentially unstable, spine injury without apparent neurologic compromise; 4) an unstable spine injury with neurologic compromise; and 5) a severely injured patient with unknown spinal injury status. If immobilization is to be used, it would be indicated for numbers 3, 4, and 5.

"Clearing the spine" has many definitions depending on circumstances and training level of the provider, and is generally regarded as more vernacular than academic. For instance, depending on the professional circle, a cleared patient may have no spine injury, have a low enough probability of injury to not need a board or collar and not need radiographic imaging based on decision rule criteria (eg, National Emergency X-radiography Utilization Study [NEXUS]), or have had radiographic imaging with no demonstrable injury. Further, some wilderness medicine educational organizations teach that clearing the spine is performed only for evacuation purposes, and should then be followed by formal evaluation by an advanced medical provider.

For the purpose of this manuscript, clearing the spine refers to the process of either correctly identifying number 1 or 2 above, or perhaps more importantly ruling out numbers 3, 4, and 5. A patient may have symptoms or physical findings associated with a spinal injury of no acute consequence (number 2) including sprains, strains, and even mild fractures (eg, spinous process or mild compression fracture). Some of these injuries may even result in longer-term symptoms that may require medical attention at a later date (eg, a strain that progresses to chronic symptoms amenable to medication or physical or massage therapies). If a provider clears the spine, the important distinction is that the injury is and will continue to be in the number 2 category with a probability of less than 1% of missing a number 3, 4, or 5 category injury.

Results

Guidelines related to spinal immobilization, the evidence supporting them, and their recommendation grades are described.

PREFERRED POSITION FOR THE INJURED SPINE

Although no studies have specifically evaluated an optimal generic position for the injured spine, clinical evidence (derived from imaging and patient care experience with traction, manipulation, and operative reduction) would strongly suggest that neutral alignment is preferred.

Recommendation

Neutral alignment should be restored and maintained with light to moderate manual cervical traction during extrication, unless such a maneuver is met with resistance, increased pain, or new or worsening neurologic deficit. Recommendation grade: 1C.

METHODS OF EXTRICATION WITH POSSIBLE CERVICAL SPINE INJURY

Shafer and Naunheim[27] published a study analyzing neck motion during extrication from a mock automobile using an infrared 6-camera motion-capture system. Compared with extrication by experienced paramedics, allowing an individual to exit the vehicle under his own volition with cervical collar in place resulted in the least motion of the cervical spine. A similar biomechanical study recently corroborated these findings.[28]

A radiographic comparison showed superior immobilization of the normal cervical spine during extrication from an automobile with a Kendrick extrication device (KED) plus Philadelphia collar compared with short board, tape, and collar.[29] Similar benefit has been demonstrated in other studies with the KED and similar devices.[30–32]

Recommendation

Patients requiring extrication, when the cervical spine cannot be cleared before extrication, should be placed in a cervical collar and allowed to exit the situation under their own volition if alert and reliable. Otherwise extrication should be performed with a KED (or similar device) plus cervical collar, and the immobilized patient moved in a sitting position onto a long spine board, vacuum mattress, or similar device. Recommendation grade: 1C.

MOVING THE PATIENT WITH REAL OR POTENTIAL SPINE INJURY

Manual cervical traction is the standard technique for moving patients with known spine trauma in the hospital setting. This is done in an effort to keep the spine in the anatomic position and to prevent distortion of the spine that might occur otherwise. Traction is often used for stabilization and reduction of unstable spine injuries. In the monitored hospital setting, up to 150 pounds of cervical traction has been used safely in the reduction of unstable spine injuries.[33] Excessive traction can be dangerous in a grossly unstable spine injury and, therefore, should be avoided in the unmonitored setting.

Recommendation

Light to moderate traction should be used when returning a cervical spine to the anatomic position and transferring a patient. Recommendation grade: 1C.

Boissy et al[34] demonstrated superior stabilization of the entire spine with lift and slide transfer to a backboard compared with log-roll. This study also compared 2 methods of providing additional manual cervical spine stabilization relative to maintaining simultaneous stabilization of the thoracolumbar spine: the head squeeze and the trap squeeze. With the head squeeze maneuver, the lead rescuer lets the patient's head rest in the palms, hands on both sides of the head with fingers placed so that the ulnar fingers can grab the mastoid process below and the second and third fingers can apply a jaw thrust if necessary. With the trap squeeze, the rescuer grabs the patient's trapezius muscles on either side of the head with his or her hands (thumbs anterior to the trapezius

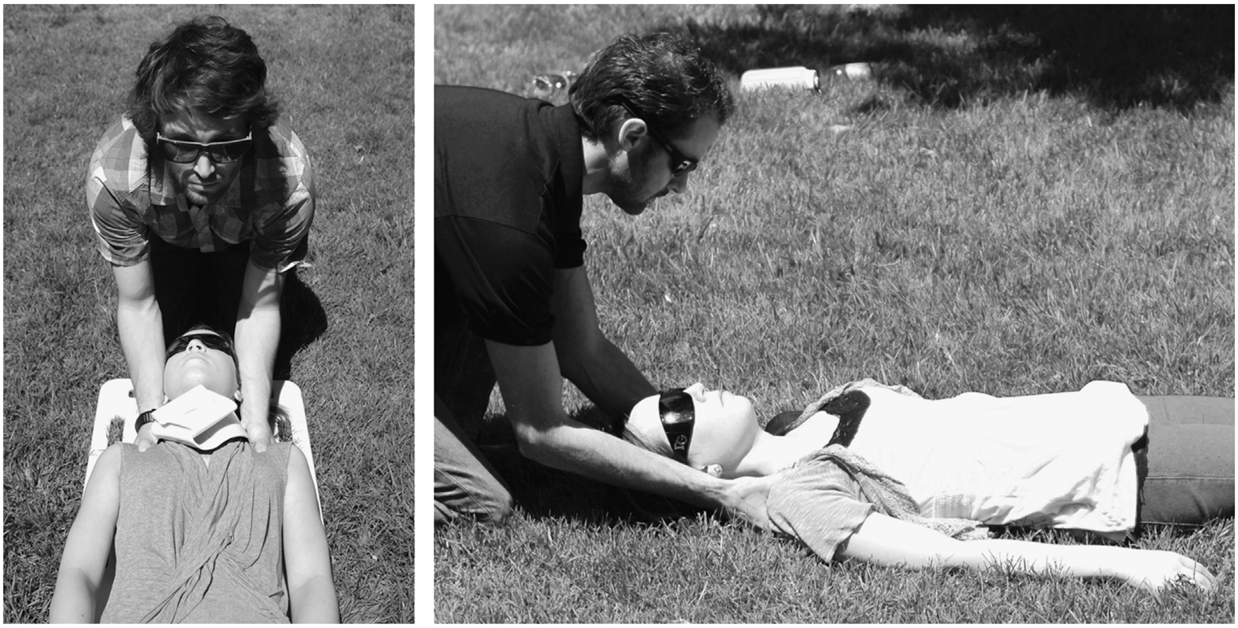

Figure 1. (A, B) Demonstration of trap-squeeze technique for manual cervical spine stabilization.

muscle) and firmly squeezes the head between the forearms with the forearms placed approximately at the level of the ears (Figure 1). The trap squeeze was superior to the head squeeze in this study, particularly with simulation of an agitated patient.

The superiority of the lift and slide transfer over the log-roll in providing stabilization of the entire spine has also been demonstrated in other studies.[35,36]

Recommendation

The lift and slide transfer with trap squeeze is preferred to the log-roll when transferring patients to and from a backboard. Recommendation grade: 1C.

We are unaware of any evidence that would preclude transportation in the lateral decubitus position. Spine-injured patients are frequently placed in the lateral decubitus position when hospitalized without ill effect.

EFFECTIVENESS OF SPINAL IMMOBILIZATION IN REDUCING THE INCIDENCE OF NEUROLOGIC SEQUELAE

A Cochrane review found no randomized controlled trials of spinal immobilization. The authors of that review conclude that the effect of spinal immobilization on mortality, neurologic injury, spinal stability, and adverse effects in trauma patients remains uncertain.[2] Because airway obstruction is a major cause of preventable death in trauma patients and spinal immobilization can contribute to airway compromise, the authors also concluded that the possibility that immobilization may increase morbidity and mortality cannot be excluded.

Hauswald et al[37] reported a retrospective review of all patients reporting to 2 university hospitals with acute blunt traumatic spinal or spinal cord injuries who were transported directly from the injury site to the hospital. None of 120 patients treated at one university hospital had spinal immobilization during transport, whereas all 334 patients treated at the other university did. There was less neurologic disability in the patients who were not immobilized (odds ratio, 2.03; 95% CI, 1.03–3.99; $P = .04$).

Recommendation

Spinal immobilization should be considered in the patient with evidence of spinal injury, including those with neurologic injury and those patients with severe trauma and who are unconscious or exhibit altered mental status. Recommendation grade: 2C.

EFFECTIVENESS OF THE CERVICAL COLLAR IN IMMOBILIZATION OF THE CERVICAL SPINE

Although use of the cervical collar is considered the gold standard in immobilization of the cervical spine, little evidence exists to support its effectiveness. An assumption exists that the neutral anatomic position is desired with an injured spine, and that the cervical collar accomplishes this goal. However, one study demonstrated that more than 80% of adults require 1.3 to 5.1 cm of occipital padding in addition to a cervical collar to maintain the cervical spine in the neutral position relative to the torso, dependent on physical characteristics and muscle development.[38]

A separate assumption exists that the cervical collar restricts motion of the cervical spine. However, using a cadaver model, Horodyski et al[39] concluded that using a cervical collar was better than no immobilization, but that it did not effectively reduce motion in an unstable spine model. Another cadaveric study analyzed cervical motion with no collar and with 3 different cervical collar types.[36] Although there was a decrease in the amount of motion generated in every plane of motion as a result of wearing each of the 3 collars, none of the changes proved to be significantly different. Holla[40] showed that a rigid cervical collar combined with a backboard reduced cervical motion to 34% of normal. Use of head blocks and a backboard reduced motion to 12% of normal. Addition of a rigid cervical collar to the use of head blocks provided no added immobilization benefit but did limit mouth opening. These results have been somewhat contradicted by Podolsky et al,[41] who demonstrated in a similar study that neither collars alone nor sandbags and tape provided satisfactory restriction of cervical spine motion. In their study, addition of a rigid cervical collar to the sandbags and tape resulted in a statistically significant reduction in neck extension. Lador et al,[42] using a cadaveric model, demonstrated cervical distraction at the site of injury with the use of a rigid collar, as well as creation of a pivot point in the cervical spine where the collar meets the skull and shoulders. Others have also demonstrated abnormal separation between vertebrae with the use of cervical collars in the presence of a dissociative injury.[43] Ivancic[44] performed a biomechanical investigation of 2 types of cervical collars and 2 types of cervicothoracic orthoses. Even though this study demonstrated increasing effectiveness of immobilization with the more constrained devices, particularly with middle and lower cervical spine flexion and extension, the most restrictive device still allowed 57.8% of axial rotation and 53.8% of lateral bending.

Independent of whether or not cervical collars are effective, their use may be associated with complications related to the collar itself. Cervical orthoses can increase the risk of aspiration and impede the ability to establish an adequate airway. Additionally, these devices have been shown to directly compromise respiration. Ay et al[21] demonstrated statistically significant decreases in forced expiratory volume in 1 second (FEV_1) and forced vital capacity with both the KED and long spinal backboard. Another study showed a 15% decrease in FEV_1 with a cervical collar and backboard, and noted that respiratory restriction was more pronounced with age.[13] Others have demonstrated similar findings.[18,19,21] Cervical collars have also been associated with elevated intracranial pressure,[45–48] and pressure ulceration associated with the use of rigid cervical collars has been well documented.[26,49–52]

Although the expert panel remains unaware of any specific cases of documented neurologic deterioration occurring secondary to absent or inadequate prehospital immobilization, many cases of documented neurologic deterioration, and even death, have now been reported with the use of a cervical collar in patients with ankylosing spondylitis.[22,23] In these patients, the rigid collar places the fragile cervical spine in a compromised position and should be considered contraindicated.

When properly applied, an improvised SAM splint cervical collar can be as effective as a Philadelphia collar.[53]

Recommendation

The cervical collar (or improvised equivalent) should be considered one of several tools available to aid in immobilization of the cervical spine. It should not be considered adequate immobilization in and of itself, nor should it be considered necessary if adequate immobilization can be accomplished by other means, or if the presence of the collar in itself compromises emergent patient care. Recommendation grade: 2B.

Recommendation

Use of the cervical collar is contraindicated in ankylosing spondylitis. Patients with suspected injury should have their neck supported in a position of comfort. Recommendation grade 1B.

EFFECTIVENESS OF THE BACKBOARD

Several studies have demonstrated that a vacuum mattress provides significantly superior spine stability, increased speed of application, and markedly improved patient comfort when compared with a backboard.[54–59] Vacuum mattress immobilization of the potentially injured spine is the current recommendation of the International Commission for Mountain Emergency Medicine.[60]

Recommendation

Vacuum mattress provides superior immobilization, with or without a standard cervical collar, and improved patient comfort (with corresponding decreased risk of pressure sores) and is preferred over a backboard for immobilization of either the entire spine or specific segments of concern. Recommendation grade 1C.

IMMOBILIZING THE CERVICAL SPINE

Anderson et al[61] have performed a meta-analysis of data related to clinical decision making around the use of immobilization of the asymptomatic cervical spine in blunt trauma patients. Data were derived from both in-hospital and prehospital settings. Their analysis revealed that an alert, asymptomatic patient without a distracting injury or neurologic deficit who is able to complete a functional range-of-motion examination may safely avoid cervical spine immobilization without radiographic evaluation (sensitivity, 98.1%, specificity, 35.4%; negative predictive value, 99.8%; positive predictive value, 3.7%).

NEXUS prospectively evaluated 5 parameters in selected emergency department patients with blunt trauma: no midline cervical tenderness, no focal neurologic deficits, normal alertness, no intoxication, and no painful or distracting injury.[62] Approximately 34,000 patients were evaluated, and cervical spine injuries were identified in 818, 578 of which were clinically significant. All but 8 of the 818 patients were identified using the criteria (sensitivity, 99.0%; specificity, 12.9%; negative predictive value, 99.8%; positive predictive value, 2.7%). Only 2 of the 8 had a clinically significant injury, 1 of which required surgery.

Although the sensitivity and negative predictive values quoted in both of these studies provide reassurance that injuries are not being missed, the low specificity and positive predictive value would indicate that a large number of patients (96.3% to 97.3%) are still being immobilized unnecessarily.

Domeier et al[63] prospectively collected EMS data on 8975 patients with regard to 5 prehospital clinical criteria —altered mental status, neurologic deficit, spine pain or tenderness, evidence of intoxication, or suspected extremity fracture—the absence of which identify prehospital trauma patients without a significant spine injury. They identified 295 patients with spine injuries (3.3%). Spine injury was identified by the prehospital criteria in 280 of 295 (94.4%). The criteria missed 15 patients. Thirteen of 15 had stable injuries (stable compression or vertebral process injuries). The remaining 2 would have been captured by more accurate prehospital evaluation. A similar prospective study with the same criteria collected data on 13,483 patients.[64] Sensitivity of the EMS protocol was 92%, resulting in nonimmobilization of 8% of the patients with spine injuries, none of which developed neurologic compromise.

Maine has used a prehospital selective spine assessment protocol since 2002. Patients with qualified mechanism of injury (axial load, blunt trauma, motor vehicle collision, adult fall from standing height) are not immobilized if they are reliable (no intoxication or altered mental status), have no distracting injury, have a normal neurologic examination, and have no spine pain tenderness. During one 12-month study period, only 1 patient with an unstable spine fracture and 19 stable fractures were found to have been not immobilized by the protocol in approximately 32,000 trauma encounters.[65] The protocol had a sensitivity of 94.1%, negative predictive value of 99.9%, specificity of 59.3%, and positive predictive value of 0.1%. The single unstable spine injury occurred in an 86-year-old woman who injured her back while moving furniture 1 week before calling EMS and had a T6–T7 subluxation requiring fixation without neurologic injury. Elderly patients (>65 years of age) represented the largest number of stable spine fractures without neurologic compromise, but also demonstrate a higher risk of complications (pain, pressure sores, respiratory compromise) from spinal immobilization. Further data from the same study population published separately revealed that 1301 patients of 2220 were immobilized on the basis of the protocol: 416 (32%) were unreliable, 358 (28%) were considered to have distracting injuries, 80 (6%) had an abnormal neurologic examination, and 709 (54%) had spine pain or tenderness.[66] Of the 2220 patients, only 7 acute spine fractures were identified, of which all were appropriately immobilized.

Studies have also validated the prehospital use of the Canadian C-spine protocol.[67–75] This protocol investigates 3 questions relevant to whether or not a patient requires cervical spine radiographs: 1) Is there a high-risk factor present (age older than 65, dangerous mechanism, paresthesias)? 2) Is there a low-risk factor present that allows safe assessment of range of motions (simple rear-end motor vehicle accident, ambulatory at any time since injury, sitting position in the emergency department, delayed onset of neck pain, absence of midline cervical spine tenderness)? 3) Is the patient able to actively rotate the neck 45° to the left and right?

In one study, the NEXUS criteria were compared with the Canadian C-spine criteria by 394 physicians evaluating 8283 patients, with an overall incidence of 169 (2%) of clinically important spine injuries.[73] The Canadian C-spine rule was more sensitive (99.4% vs 90.7%; $P < .001$) and more specific (45.1% vs 36.8%; $P < .001$) at detecting spine injuries.

A study of 6500 patients evaluated the relationship between mechanism of injury and spinal injury.[76] The authors concluded that the mechanism of injury does not affect the ability of clinical criteria to predict spinal injury. It should come as no surprise that this is the case and that no specific mechanism of injury will prove predictive in a meaningful capacity. There are certainly many cases in which minimal trauma can result in profound cervical spine injury with neurologic deficit (eg, an elderly patient after a minor fall). On the other hand, individuals often escape serious injury even after high-energy trauma.

Konstantinidis et al[77] reported on 101 evaluable patients with cervical spine injury. Distracting injuries were present in 88 patients (87.1%). Only 4 patients (4.0%) had no pain or tenderness on the initial examination of the cervical spine. All 4 patients had bruising and tenderness to the upper anterior chest. None of these 4 exhibited neurologic sequelae or required surgical stabilization or immobilization.

Recommendation

Appropriately trained personnel, using either the NEXUS criteria or the Canadian C-spine rule, can safely and effectively make decisions in the prehospital setting as to whether or not a cervical spine should be immobilized. Recommendation grade: 1A.

PENETRATING TRAUMA

Blunt trauma to the spine is far more common than penetrating trauma. Although penetrating trauma is more common in a military than a civilian setting, blunt trauma is still the predominant mechanism of spine injury in the military setting. One study of 598 service members who sustained spinal injury showed 66% were the result of blunt trauma, 28% penetrating trauma, and 5% combined.[78] Clinically significant spinal injury is rare in the setting of a stab wound, but not uncommon after a gunshot wound (GSW).[79] Neurologic deficit from penetrating assault is generally established and final at presentation.[17,80,81] In the civilian setting, in which GSWs are predominately low velocity, spinal instability rarely occurs. DuBose et al[81] reviewed 4204 patients sustaining GSWs to the head, neck, and torso in a civilian setting. Of these, 327 (7.8%) had bony spinal column injury. None of the 4204 patients demonstrated spinal instability, and only 2 of 327 (0.6%) required any form of operative intervention for decompression. They conclude that routine spinal imaging and immobilization is unwarranted in examinable patients without symptoms consistent with spinal injury. Lustenberger et al[82] reported similar findings.

High-velocity penetrating injury of the cervical spine is associated with a high incidence of major vascular injury and airway injury requiring advanced airway protection. Cervical spine immobilization has been associated with a higher incidence of morbidity, and even mortality, when used in the presence of penetrating cervical trauma.[15–17,20,24] Similar findings have been demonstrated in thoracic injuries.[17] Haut et al[17] evaluated 45,284 patients with penetrating trauma and showed overall mortality to be twice as high in spine-immobilized patients (14.7% vs 7.2%; $P < .001$). In their study, the number needed to treat with spine immobilization to potentially benefit 1 patient was 1032, whereas the number needed to harm with spine immobilization to potentially contribute to 1 death was 66.

The Committee on Tactical Combat Casualty Care currently recommends a balanced approach to cervical spine precautions when a significant mechanism of injury exists, but there is a need to rapidly extract the casualty away from directed action on the battlefield during care under fire.[83,84]

The Prehospital Trauma Life Support Executive Committee has performed and published a systematic review of prehospital spine immobilization for penetrating trauma.[16] They conclude that there are no data to support routine spine immobilization in patients with penetrating trauma to the cranium, neck, or torso.

Recommendation

Spinal immobilization should not be performed in the presence of penetrating trauma. Recommendation grade 1B.

Discussion

The most frequently cited articles of missed spine injuries resulting in neurologic deterioration largely reference situations that occurred after presentation to the emergency department.[8,9,14] Many of these cases had a recognized spine injury with neurologic deterioration occurring as a result of nonoperative treatment, which at the time was standard of care. In fact, the article by Bohlman[9] is considered a landmark paper in the orthopaedic literature, and the patients described formed the foundation for improved spinal injury care in the form of operative intervention. In the preponderance of the other reported cases, neurologic deterioration occurred as a result of a failure to recognize and adequately image patients in circumstances in which a high degree of suspicion of spinal injury should have been present, including 2 patients[14] who sustained neurologic injury after surgery for a traumatized aorta. Davis et al[8] reported 34 cases of missed cervical spine injuries (4.6%) in 740 trauma patients, 29% of whom had permanent neurologic sequelae. Thirty-one of 34 had inadequate or misinterpreted plain x-rays in the emergency department. Review of the elements of these cases presented in the paper would indicate that none of the patients for whom adequate data were provided would have passed either the NEXUS or Canadian C-spine criteria. In the few cases reported in which neurologic deterioration occurred in the prehospital setting, there is a presumption that these injuries were the result of inappropriate handling and lack of immobilization. Given the rarity of these types of reports, the current authors would submit, in light of recent evidence cited in this paper and elsewhere, that these episodes of neurologic deterioration are more likely a result of the injury itself.

The concept of spinal immobilization has been predicated entirely on philosophical, theoretical, and medicolegal grounds, and the justification for its use remains unchanged despite more than 4 decades of widespread use. Despite a lack of evidence clearly supporting spinal immobilization, an absence of documented cases of neurologic deterioration as a result of inadequate immobilization, and in the face of accumulating data challenging both the philosophical and theoretical grounds of immobilization, no randomized controlled trials have yet been performed in an attempt to validate its ongoing use or stratify any risk-benefit ratio. In the urban setting, the routine use of spinal immobilization likely adds little to improve the care of the injured patient, but correspondingly likely accounts for little harm to the patient (in the absence of penetrating trauma) or first responders. The financial harm to the system (if indeed there is little evidence to support routine use) is likely enormous, measured in both direct (expense of increasing the time and complexity of extrication as well as unnecessary tests and procedures) and indirect costs (inadvertently "validating" subsequent medicolegal claims of spine injury). Conversely, the routine use of spinal immobilization in the austere environment not only increases the financial cost of rescue operations, but also greatly increases the time, logistics, and complexity of the operation, thereby also exacting a cost in terms of increased morbidity and mortality to not only the patient but rescue personnel as well.

In the austere environment, the goal of spinal assessment and care should not be to definitively rule out or recognize all forms of spine injury. Rather, the goal should be to minimize the risk of missing or exacerbating a potentially unstable spine injury. The risk of missing such an injury should be appropriately calibrated against the risk of exposing rescuers to the potential for serious injury or causing further injury to the patient beyond that which occurred during the index traumatic event. In this context, it would appear that the NEXUS criteria and components of the Canadian C-spine rule are overly restrictive, particularly in regard to the mechanism of injury, when used in the austere environment to evaluate cervical spine injury. Although similar algorithms have not been developed for the thoracolumbar spine, one could argue that similar rules and conditions would be appropriately applicable.

It is fortuitous that the vacuum splint has become popular in the rescue environment. Not only is this device portable and rapidly deployable but it appears quite likely to provide superior spine immobilization in addition to its other packaging and evacuation benefits, not the least of which is enhanced patient comfort and a decreased likelihood of complications associated with a cervical collar and backboard.

After careful and meticulous review of the literature, and in combination with the collective expertise of the authors, we recommend a treatment algorithm as outlined in Figure 2.

Patients with isolated penetrating trauma should not receive spinal immobilization. However, definitive spinal evaluation should be performed on arrival at an appropriate medical center.

When patients have sustained blunt trauma, with or without concomitant penetrating trauma, the mechanism of injury must be evaluated as it relates to the overall context of the patient and scene. Judgment regarding the likelihood of associated spinal injury should be individualized, as no reasonable guidelines are practical given the wide and disparate combinations of trauma and injury. As previously discussed, given the appropriate circumstances severe spine trauma can result with minimal trauma (particularly in the elderly), yet patients can often escape serious injury after the most dramatic trauma.

If the patient is suspected of having a serious spinal injury but the spine cannot be reliably evaluated (severe injury, altered mental status, or significant distracting injury), the spine should be immobilized. The term severe injury is somewhat subjective but has been defined elsewhere as abnormal vital signs (systolic blood pressure < 90 mm Hg or respiratory rate outside of the range 10 to 24 breaths/min).[85] All patients with evidence of neurologic deficit should be immobilized. The definition of distracting injury should be considered in the same context as mechanism of injury and individualized accordingly.

If the patient has suffered a trauma suspicious for spinal injury and the spine can be reliably evaluated, responders should evaluate for significant spine pain and tenderness (≥ 7 of 10). If neither is present, immobilization is not indicated. If spine pain or tenderness is present, but less than 7 of 10, the patient should be asked to demonstrate spinal range of motion within the limits of reasonable tolerance. If the patient can voluntarily flex, extend, and rotate 30° in each plane, immobilization is not necessary but definitive evaluation should be

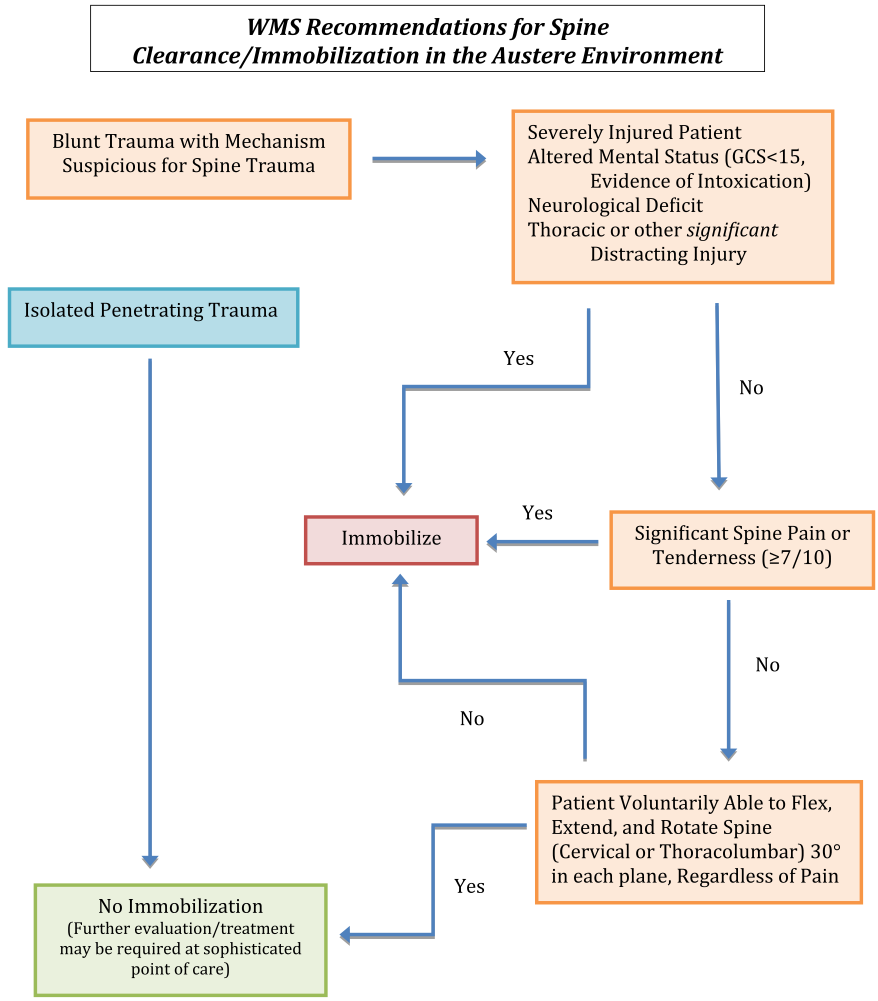

Figure 2. WMS recommendations for spine clearance and immobilization in the austere environment.

performed on arrival at an appropriate medical center. If these maneuvers cannot be performed, the patient should be immobilized.

The premise for range-of-motion testing is based on the well-validated use of flexion and extension cervical spine radiographs to clear a cervical spine. For years (before magnetic resonance imaging), this procedure served as the gold standard used to definitively clear the cervical spine, based on the knowledge that a standard lateral c-spine x-ray may appear normal in the presence of significant soft tissue injury with underlying spine instability. Flexion and extension cervical spine radiographs have been routinely performed under the direct volition of the patient under the premise that an alert patient will not cause themselves neurologic harm in the presence of an injury with the capacity to do so. To our knowledge, no adverse patient reaction has been reported after many years of use. The ability to perform the maneuver, and the extent to which range of motion should occur, should be left entirely to the alert patient; pain alone should not be used as a disqualifier to interrupt the maneuver.

Deciding whether or not to immobilize the spine using this algorithm can be safely accomplished by practitioners with at least a basic working knowledge of the fundamental elements. That is, the practitioner should be able to recognize degrees of major trauma, identify mechanisms of injury with the potential to cause spinal injury, perform a basic physical examination of the spine and neurologic system, and recognize distracting injuries.

Although the preponderance of literature concerns the cervical spine, particularly as it relates to the Canadian C-spine and NEXUS protocols, much (particularly historical literature) refers to the entire spine. Although by its nature the cervical spine is certainly more prone to injury than the thoracolumbar spine, and the potential consequences perhaps more devastating, injuries throughout the spine occur by similar mechanisms of injury and share similar pathophysiology and similar potential for neurologic injury. The authors believe that the discussions set forth in this manuscript, including the algorithm outlined in Figure 2, pertain to the entire spine, except where specifically indicated otherwise.

Conclusions

Limited evidence supports the current rationale for stabilizing the potential spine injury in the austere environment. The authors believe that the proposed algorithm offers the best compromise between unnecessary immobilization and the risk of causing further damage in the presence of spinal injury, recognizing that both have the propensity to result in further injury to the patient and rescuers in the austere environment. Although these guidelines cover many of the relevant issues related to spine injury and immobilization, questions remain that should serve as focus for future research.

POSTSCRIPT

Since the publication of our initial manuscript,[86] questions have arisen regarding our guidelines. In addition to updating the current version with newly published data, we have added some expanded discussion and, hopefully, added some clarity to the manuscript. It has been pointed out that the evidence, and consequently our recommendations, fails to support immobilization in general. If this is true, why include an algorithm for immobilization at all? We realize that the evidence currently available, although likely accurate, is not high level. This, combined with the fact that many will consider the very notion of discarding immobilization in its entirety heresy, makes our algorithm a reasonable transition to a new paradigm while allowing (and hopefully promoting) further study to improve our understanding of spine injury, spinal protection, and the quality of evidence on which to base further recommendations.

We have received several suggestions for changing our algorithm, none of which materially or substantially change the spirit of the existing one. No algorithm will address every clinical situation or be accepted by every medical provider, and situational use will likely differ. Adaptations to the algorithm that might improve the fit to alpine rescue may adversely affect the fit to swift water or cave rescue, etc. Such adaptations are encouraged at the field level when implemented by practiced and knowledgeable providers. (Also see the online Supplementary Evidence Table 2.)

Supplementary tables

Supplementary ACCP Table 1 and Evidence Table 2 are available online at doi:10.1016/j.wem.2014.08.011.

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