PRE-HOSPITAL CERVICAL SPINAL IMMOBILIZATION FOLLOWING TRAUMA

RECOMMENDATIONS

Standards: There is insufficient evidence to support treatment standards.

Guidelines: There is insufficient evidence to support treatment guidelines.

Options:

- It is suggested that all trauma patients with a cervical spinal column injury or with a mechanism of injury having the potential to cause cervical spinal injury should be immobilized at the scene and during transport using one of several available methods.
- A combination of a rigid cervical collar and supportive blocks on a backboard with straps is very effective in limiting motion of the cervical spine and is recommended. The longstanding practice of attempted cervical spinal immobilization using sandbags and tape alone is not recommended.

RATIONALE

The early management of the patient with a potential cervical spinal cord injury begins at the scene of the accident. The chief concern during the initial management of patients with potential cervical spinal injuries is that neurologic function may be impaired due to pathologic motion of the injured vertebrae. It is estimated that 3% to 25% of spinal cord injuries occur after the initial traumatic insult, either during transit or early in the course of management.(11,12,40,46,78,92) Multiple cases of poor outcome from mishandling of cervical spinal injuries have been reported.(9,49,78,92) As many as 20% of spinal column injuries involve multiple non-continuous vertebral levels, therefore the entire spinal column is potentially at risk.(36,37,65,70) Consequently, complete spinal immobilization has been used in pre-hospital spinal

care to limit motion until injury has been ruled out. (20,25,38,65,70,73,95, 98,101) Over the last 30 years there has been a dramatic improvement in the neurologic status of spinal cord injured patients arriving in emergency departments. During the 1970's the majority (55%) of patients referred to Regional Spinal Cord Injury Centers arrived with complete neurological lesions. In the 1980's, however, the majority (61%) of spinal cord injured patients arrived with incomplete lesions.(44) This improvement in the neurologic status of patients has been attributed to the development of Emergency Medical Services (EMS) initiated in 1971, and the pre-hospital care (including spinal immobilization) rendered by EMS personnel. (20,43,44,100) Spinal immobilization is now an integral part of pre-hospital management and is advocated for all patients with potential spinal injury following trauma by EMS programs nationwide and by the American College of Surgeons.(1,2,13,20,30,67,88,95)

Recently, the use of spinal immobilization for all trauma patients, particularly those with a low likelihood of traumatic cervical spinal injury has been questioned. It is unlikely that all patients rescued from the scene of an accident or site of traumatic injury require spinal immobilization.(31,48,66,74) Some authors have developed and advocate a triage system based on clinical criteria to select patients for pre-hospital spinal immobilization.(10,30,71)

Several devices are available for pre-hospital immobilization of the potential spine injured patient. However, the optimal device has not yet been identified by careful comparative analysis. (14,18,25,51,58,61,89,97) The recommendations of the American College of Surgeons consist of a hard backboard, a rigid cervical collar, lateral support devices, and tape or straps to secure the patient, the collar and the lateral support devices to the backboard. (94,95) A more uniform, universally accepted method for pre-hospital spinal immobilization for patients with potential spinal injury following trauma may reduce the cost and improve the efficiency of pre-hospital

spinal injury management.(10,30,71) While spinal immobilization is typically effective in limiting motion, it has been associated with morbidity in a small percentage of cases. (6,15,16,24,53,84,93,98)

These issues are the subject of this review on the use and effectiveness of pre-hospital spinal immobilization.

SEARCH CRITERIA

A National Library of Medicine computerized literature search from 1966 to 2001 using the medical subject heading "spinal immobilization" was performed. The search was limited to human subjects and the English language. A total of 39 articles were accessed. A second search combining the exploded terms "spinal injuries" and "immobilization" yielded 122 articles. A third search combining the exploded terms "spinal injuries" and "transportation of patients" yielded 47 articles. A fourth search combining the exploded terms "spinal injuries" and "emergency medical services" produced 119 articles. Additional references were culled from the reference lists of the remaining papers. Finally, the author group was asked to contribute articles known to them on the subject matter that were not found by other search methods. Duplicate references were discarded. The abstracts were reviewed and articles unrelated to the specific topic were eliminated. This process yielded a total of 100 articles for this review which are listed in the bibliography. Articles used to formulate this guideline are summarized in Evidentiary Table format.

SCIENTIFIC FOUNDATION

Pathologic motion of the injured cervical spine may create or exacerbate cervical spinal cord or cervical nerve root injury.(36,37,38,65,70,91) This potential has lead to the use of spinal immobilization for trauma patients who have sustained a cervical vertebral column injury or experienced a mechanism of injury that could result in cervical spinal column injury. (2,25,33,31,38,65,70,71,73,95,101)

Kossuth is credited with pioneering the currently accepted methods of protection and immobilization of the cervical spine during extrication of acute injury victims.(54,55) Farrington championed the concept of pre-hospital immobilization. (34,35) Dick and Land noted in their review of spinal immobilization devices that techniques of pre-hospital spinal immobilization appeared in standard EMS texts and in the American Academy of Orthopedic Surgeons Committee on Injuries Emergency text as early as 1971.(20,28) Initially, the preferred method to immobilize the cervical spine was the use of a combination of a soft collar and a rolled up blanket.(18) This was followed by the introduction of a more rigid extrication collar by Hare in 1974. Hare's contribution launched an era of innovation for devices for spinal immobilization.(25)

Currently, spinal immobilization is one the most frequently performed procedures in the pre-hospital care of acute trauma patients in North America. (2,3,20,25,36,38,65,70,73,96,101) While clinical and biomechanical evidence demonstrate that spinal immobilization limits pathologic motion of the injured spinal column, there is no Class I or Class II medical evidence to support spinal column immobilization in all patients following trauma. While immobilization of an unstable cervical spinal injury makes good sense, and Class III evidence reports exist of neurological worsening with failure of adequate spinal immobilization, there have been no case-controlled studies or randomized trials that address the impact of spinal immobilization on clinical

outcomes following cervical spinal column injury. (2,25,30,38,40,46,48,65,66,70,92) The issue is important; tens of thousands of trauma victims are treated with spinal immobilization each year, yet few will have spinal column injuries or instability.(37,71,79)

Other considerations in the use of pre-hospital spinal immobilization include the cost of equipment, the time and training of EMS personnel to apply the devices, and the unnecessary potential morbidity for patients who do not need spinal immobilization following trauma.(6,15,16,24,25,53,56,80,84,93,98) As with many interventions in the practice of medicine, spinal immobilization has been instituted in the pre-hospital management of trauma victims with potential spinal injuries based on the principles of neural injury prevention and years of clinical experience, but without supportive scientific evidence from rigorous clinical trials. For a variety of both practical and ethical reasons it is likely impossible to obtain this information in clinical trials in contemporary times.

In 1989 Garfin stated that "no patient should be extricated from a crashed vehicle or transported from an accident scene without spinal stabilization". In his review, he credited stabilization of the cervical spine as a key factor in the decline in the percentage of complete spinal cord injury lesions from 55% in the 1970's to 39% in the 1980's and in the significant reduction in the mortality of multiple injury patients with cervical spinal injuries.(38) Unfortunately, there is no Class I or Class II medical evidence to support his claims.

Few articles have directly evaluated the effect of pre-hospital spinal immobilization on neurological outcome after injury. Several Class III evidence reports cite the lack of immobilization as a cause of neurological deterioration among acutely injured trauma patients transported to medical facilities for definitive care. (9,38,49,59,78) The most pertinent study is a

retrospective case series of Toscano et al, who in 1988 reported that 32 of 123 trauma patients (26%) they managed sustained major neurological deterioration in the period of time between injury and admission. The authors attributed neurological deterioration to patient mishandling and cited the lack of spinal immobilization after traumatic injury as the primary cause. Their report supports the need for pre-hospital spinal immobilization of trauma patients with potential spinal column injuries.(92)

In contrast, a collaborative, 5-year retrospective chart review reported by the University of New Mexico and the University of Malaya challenges this position. Hauswald et al analyzed only patients with acute blunt spinal or spinal cord injuries. At the University of Malaya, none of the 120 patients they managed were immobilized with spinal orthoses during transport. All 334 patients managed at the University of New Mexico were initially treated with spinal immobilization. Both hospitals were reportedly comparable with respect to physician training and clinical resources. Two independent physicians blinded to the participating hospital characterized the neurological injuries into two groups: disabling and non-disabling. Data were analyzed using logistic regression techniques, with hospital, patient age, gender, anatomic level of injury, and injury mechanism as variables. Neurological deterioration after injury was less frequent in Malayan patients with spinal injuries who were not treated with formal spinal immobilization during transport (OR 2.03; 95% CI 1.03-3.99; $p = 0.04$), compared to patients in New Mexico who were managed with spinal column immobilization techniques. Even when the analysis was limited to cervical spine injuries, no significant protective effect from spinal immobilization was identified. The authors theorized that since the initial injury is of tremendous force, further movement of the spine by the patient or rescuers is insufficient to cause further injury. However, they noted that because of the small sample size, the benefit of spinal immobilization might not

have been statistically measurable in their study.(48) This report has been challenged and several flaws identified: Patients who died at the scene or during transport were excluded from analysis. Injuries were not matched by severity of neurological injury or by type of spinal column injury. The mechanisms of injury differed dramatically in the two populations. Malayan patients were immobilized or held immobile during transport but spinal orthoses as immobilization devices were not employed. For these reasons and others, the conclusions drawn by the authors are considered spurious at best. (25,74)

Evidence in the literature evaluating the effectiveness of pre-hospital spinal immobilization is sparse. The Hauswald paper was published in 1998 after a significant period of time during which universal spinal immobilization following trauma had been applied in the United States and North America. Ethical and practical issues preclude the execution of a contemporary clinical trial designed to study the effectiveness of pre-hospital spinal immobilization compared to no immobilization, primarily because spinal immobilization for trauma patients is perceived as essential with minimal risk, and is already widely employed. Intuitively, the use of pre-hospital spinal immobilization is a rational means of limiting spinal motion in spinal injured patients in an effort to reduce the likelihood of neurological deterioration due to pathological motion at the site(s) of injury.

The consensus opinion from all articles reviewed (Class III evidence), from an anatomic and biomechanical perspective and from time-tested clinical experience with traumatic spinal injuries is that all patients with cervical spinal column injuries, or those with the potential for a cervical spinal injury following trauma, should be treated with spinal column immobilization until injury has been excluded or definitive management has been initiated. While there is insufficient medical evidence to support a treatment standard or a treatment guideline, practitioners are

strongly encouraged to provide spinal immobilization to spine injured patients (or those with a likelihood of spinal injury) until definitive assessment can be accomplished.

Orledge and Pepe in their commentary on the Hauswald findings point out some limitations of their paper, but also suggest that it raises the issue of a more selective evidence-based protocol for spinal immobilization.(74) Should all trauma patients be managed with spinal immobilization until spinal injury has been excluded, or should immobilization be selectively employed for patients with potential spinal injury based on well-defined clinical criteria? Which clinical criteria should be used? Following the Hauswald report, prospective studies in support of the use of clinical findings as indicators for the need for pre-hospital spinal immobilization after trauma have been reported.(31-33) Several EMS systems now employ clinical protocols to help guide which patients should be managed with spinal immobilization after trauma.(4,41)

Domeier et al, in a multicenter prospective study of 6,500 trauma patients found that the application of clinical criteria (altered mental status, focal neurologic deficit, evidence of intoxication, spinal pain or tenderness, or suspected extremity fracture), was predictive of the majority of patients who sustained cervical spinal injuries requiring immobilization. The predictive value of their criteria held for patients with high or low risk mechanisms of injury.(30,31,33) They suggested that clinical criteria rather than the mechanism of injury be evaluated as the standard by which spinal immobilization be employed.

Brown et al examined whether EMS providers could accurately apply clinical criteria to clear the cervical spines of trauma patients prior to transport to a definitive care facility. (10) The criteria included the presence of pain or tenderness of the cervical spine; the presence of a neurological deficit; an altered level of consciousness; evidence of drug use or intoxication

(particularly alcohol, analgesics, sedatives, or stimulants); and/or the presence of other significant trauma that might act as a distracting injury. Immobilization of the cervical spine was initiated if any one of six criteria was present. The clinical assessment of trauma patients by EMS providers was compared to the clinical assessment provided by emergency physicians. The providers (EMTs and ER MDs) were blinded to each other's assessments. Agreement between EMS and MD providers was analyzed by the kappa statistic. Five hundred seventy-three patients were included in the study. The assessments matched in 79% of the cases (n = 451). There were 78 patients (13.6%) for whom the EMS clinical assessment indicated spinal immobilization, but the MD assessment did not. There were 44 patients (7.7%) for whom the MD clinical assessment indicated spinal immobilization, but the EMS assessment did not. The kappa for the individual components ranged from 0.35 to 0.81. The kappa value for the decision to immobilize was 0.48. The EMS clinical assessments were generally more in favor of immobilization than the physician clinical assessments. The authors concluded that EMS and MD clinical assessments to rule out cervical spinal injury after trauma have moderate to substantial agreement. The authors recommended, however, that systems that allow EMS personnel to decide whether to immobilize patients after trauma should provide attentive follow-up of those patients to ensure appropriate care and to provide immediate feedback to the EMS providers.(10) Meldon et al, in an earlier study, found significant disagreement between the clinical assessments and subsequent spinal immobilization of patients between EMS technicians and MDs. They recommended further research and education before widespread implementation of this practice.(69)

Clinical criteria to select appropriate patients for spinal immobilization are being studied in Michigan (4) and have been implemented in Maine (41) and San Mateo County, California.(84) Recommendations regarding the adoption of EMS protocols for pre-hospital spinal

immobilization awaits definitive studies of safety and efficacy.(21) EMS personnel who make these assessments require intensive education and careful, quality assurance scrutiny to ensure that trauma patients with potential spinal injuries are appropriately triaged and managed.

While awaiting further studies, the available Class III studies supports the use of spinal immobilization for all patients with the potential of a cervical spinal injury following trauma.

Methods of Pre-hospital Spinal Immobilization

Pre-hospital spinal immobilization is effective in limiting spinal motion during patient transport.(3,25,38,65,70,101) Various devices and techniques exist to provide immobilization of the cervical spine. Attempts to define the best method of spinal immobilization for pre-hospital transport have been hampered by physical and ethical constraints. (14,25,51,58,61,89,97)

The methods of measuring the efficacy of spinal immobilization devices vary among investigators. Comparative studies of the various devices have been performed on normal human volunteers but none have been tested in a large number of patients with spinal injury. It is difficult to extrapolate normative data to injured patients with spinal instability.(14,17,22,25,27,47,50,51,56,62,63,75,89,96,97)

Several methods have been used to measure movement of the cervical spine. They range from clinical assessment, plumb lines, photography, radiography, cinematography, CT and MRI. Roozmon et al, summarized the problems inherent in each method and concluded that there was no satisfactory noninvasive means of studying neck motion, particularly if one is to quantify movement between individual vertebral segments.(82)

The position in which the injured spine should be placed and held immobile - the "neutral position", is poorly defined.(23,26,72,84,87) Schriger defined the neutral position as, "the normal

anatomic position of the head and torso that one assumes when standing and looking ahead." This position correlates to 12 degrees of cervical spine extension on a lateral radiograph.(84) Schriger comments that the extant radiographic definition of neutral position was based on radiographic study of patients who were visually observed to be in neutral position. (84) Schriger et al used this position in their evaluation of occipital padding on spinal immobilization backboards.(87) De Lorenzo et al, in their MRI study of 19 adults, found that a slight degree of flexion equivalent to 2 cm of occiput elevation produces a favorable increase in spinal canal/spinal cord ratio at levels C5 and C6, a region of frequent unstable cervical spine injuries.(26) Backboards have been used for years for extrication and immobilization of spine injured patients. Schriger questioned the ability of a flat board to allow neutral positioning of the cervical spine. They compared spinal immobilization employing the flat backboard with and without occipital padding in 100 adults. Clinical observation and assessment were used to determine the neutral position of the cervical spine. The authors found that the use of occipital padding in conjunction with a rigid backboard places the cervical spine in optimal neutral position compared to positioning on a flat backboard alone.(87,88) McSwain determined that more than 80% of adults require 1.3 cm to 5.1 cm of padding to achieve neutral positioning of the head and neck with respect to the torso and noted that body habitus and muscular development alter the cervical-thoracic angle, thus affecting positioning.(68) This makes it impossible to dictate specific recommendations for padding.

In general, spinal immobilization consists of a cervical collar; supports on either side of the head; and the long and short backboards with associated straps to attach and immobilize the entire body to the board.(25) Garth proposed performance standards for cervical extrication collars but these standards have not been uniformly implemented.(39) There are a variety of different

cervical collars. Several studies compare collars alone or in combination with other immobilization devices employing a wide range of assessment criteria.(14,15,17,22,89,97)

Podolsky et al in 1983, evaluated the efficacy of cervical spine immobilization techniques utilizing goniometric measures.(77) Twenty-five healthy volunteers lying supine on a rigid emergency department resuscitation table were asked to actively move their necks as far as possible in six ways: flexion, extension, rotation to the right and left, and lateral bending to the right and left. Control measurements were made with no device and measurements were repeated following immobilization in a soft collar, hard collar, extrication collar, Philadelphia collar, bilateral sandbags joined with 3-inch-wide cloth tape across the forehead attached to either side of the resuscitation table, and the combination of sandbags, tape, and a Philadelphia collar. Hard foam and hard plastic collars were superior at limiting cervical spine motion compared to soft foam collars. Neither collars alone nor sandbags and tape in combination provided satisfactory restriction of cervical spine motion. Sandbags and tape immobilization was significantly better than any of the other methods of attempted cervical spinal immobilization used alone, for all six cervical spinal movements. The authors found that sandbags and tape in combination with a rigid cervical collar was the best means of those evaluated to limit cervical spine motion, particularly because the addition of a Philadelphia collar to the sandbag and tape construct was significantly more effective in reducing neck extension ($p < 0.01$), from 15 degrees to 7.4 degrees, a change of 49.3%. Collar use had no significant additive effect for any other motion of the cervical spine. Sandbags as adjuncts to cervical spinal immobilization require more attention from care providers rather than less.(52) Sandbags are heavy and if the extrication board is tipped side to side during evacuation and transport, the sandbags can slide, resulting in lateral displacement of the victim's head and neck with respect to their torso. Sandbags can be taped in proper position to the

extrication board, but because they are small compared to the patient, this can be difficult and/or ineffective. Finally, they must be removed prior to initial lateral cervical spine x-ray assessment because they can obscure the radiographic bony anatomy of the cervical spine. For these reasons and the findings by Podolsky et al, sandbags and tape alone to attempt to immobilize the cervical spine is not recommended.(52,76)

In 1985, Cline compared methods of cervical spinal immobilization used in pre-hospital transport. They found that strapping the patient to a standard short board was superior to cervical collar use alone.(18) They noted no significant differences between the rigid collars they tested. McCabe and colleagues compared four different collars for their ability to restrict motion in flexion-extension, and lateral bending using radiographic assessment. They found that the Polyethylene-1 collar provided the most restriction of motion of the cervical spine, particularly with flexion.(62) Rosen in 1992 compared limitation of cervical spinal movement of four rigid cervical collars in 15 adults utilizing goniometric measurements. The vacuum splint cervical collar provided the most effective restriction of motion of the cervical spine of the four devices they tested.(86)

Graziano compared pre-hospital cervical spine immobilization methods by measuring cervical motion radiographically in the coronal and sagittal planes in 45 immobilized adults. The Kendricks extrication device and the Extrication Plus-One device were nearly as effective in limiting cervical motion as the short immobilization board in their study. Both devices were superior to a rigid cervical collar alone.(42)

Cohen in 1990 described the Russell Extrication device (RED) for immobilization of patients with potential spine injuries. The RED was comparable to the short immobilization board for pre-hospital spinal immobilization.(19) Chandler et al compared a rigid cervical extrication

collar with the Ammerman halo orthosis in 20 males. The Ammerman halo orthosis in combination with a rigid spine board provided significantly better cervical spinal immobilization than a cervical collar and spine board. The Ammerman halo orthosis and spine board was equivalent to the standard halo vest immobilization device.(17)

Perry et al evaluated three cervical spine immobilization devices during simulated vehicle motion in six adults. Neck motion was assessed by three neurologists and neurosurgeons as to whether motion was "clinically significant". They found that substantial head motion occurred during simulated vehicle motion regardless of the method of immobilization.(75) They observed that the efficacy of cervical spine immobilization was limited unless the motion of the head and the trunk was also controlled effectively. Mazolewski et al tested the effectiveness of strapping techniques to reduce lateral motion of the spine of adults restrained on a backboard. Subjects were restrained on a wooden backboard with four different strapping techniques. The backboard was rolled to the side, and lateral motion of the torso was measured. The authors found that additional strapping securing the torso to backboard reduced lateral motion of the torso.(61)

Finally, the traditional method of moving a patient onto a long backboard has typically involved the logroll maneuver. The effectiveness of this transfer technique has been questioned.(29,83) Significant lateral motion of the lumbar spine has been reported to occur.(64,90) Alternatives to the logroll maneuver include the HAINES method and the multi-hand or fireman lift method.(45,93,95) In the HAINES method (acronym for High Arm IN Endangered Spine), the patient is placed supine, the upper arm away from the kneeling rescuer is abducted to 180 degrees, the near arm of the patient is placed across the patient's chest, and both lower limbs are flexed. The rescuer's hands stabilize the head and neck and the patient is rolled away onto an extrication board or device.(45) The multihand or fireman lift method involves

several rescuers on either side of the patient each of whom slides their arms underneath the patient and lifts the patient from one position to the another onto an extrication board or device.

The above review depicts the evolution of and underscores the diversity of techniques available for providing pre-hospital spinal immobilization of spinal injured patients during transport. These studies are limited by the fact that none of the studies evaluates the full range of available devices using similar criteria. Overall, it appears that a combination of rigid cervical collar immobilization with supportive blocks on a rigid backboard with straps to secure the entire body of the patient is most effective in limiting motion of the cervical spine after traumatic injury.(95) The longstanding practice of attempted spinal immobilization using sandbags and tape alone is insufficient.

Safety of Pre-hospital Spinal Immobilization Devices

Despite obvious benefits, cervical spinal immobilization has a few potential drawbacks. Immobilization can be uncomfortable, it takes time to apply, application may delay transport and it is associated with modest morbidity.(6,15,16,24,84,93,98)

Chan et al studied the effects of spinal immobilization on pain and discomfort in twenty-one non-injured adults. Subjects were placed in backboard immobilization for 30-minutes and symptoms were chronicled. All subjects developed pain which was described as moderate to severe in 55% of volunteers. Occipital headache, sacral, lumbar and mandibular pain were the most frequent complaints.(16) In a later study, Chan and others compared spinal immobilization on a backboard to immobilization with a vacuum mattress-splint device in 37 normal adults. The authors found that the frequency and severity of occipital and lumbosacral pain was significantly greater during backboard immobilization than on the vacuum mattress-splint device. Johnson and

Hauswald performed a prospective, comparative study of the vacuum splint device versus the rigid backboard. The vacuum splint device was significantly more comfortable than the rigid backboard and was faster to apply. The vacuum splint device provided better immobilization of the torso. The rigid backboard with head blocks was slightly better at immobilizing the head. Vacuum splint devices, however, are not recommended for extrication because they are reportedly not rigid enough, and they are more expensive. At a cost of approximately $400, the vacuum splint device is roughly three times more expensive than a rigid backboard. (16)

Hamilton studied the comfort level of 26 adults on a full-body vacuum splint device compared to a rigid backboard, with and without cervical collars. Subjects graded their immobilization and discomfort. No statistically significant difference was found between the vacuum splint device and collar combination compared to the backboard-collar combination for flexion and rotation. The vacuum splint-collar combination provided significantly superior immobilization in extension and lateral bending than the backboard-collar combination. The vacuum splint alone, provided superior cervical spinal immobilization in all neck positions except extension, compared to the rigid backboard alone. A statistically significant difference in subjective perception of immobilization was noted, with the backboard alone less effective than the other three alternatives. In conclusion, the vacuum splint device, particularly when used with a cervical collar is an effective and comfortable alternative to a rigid backboard (+/- collar) for cervical spinal immobilization.(47)

Barney et al evaluated pain and discomfort during immobilization on rigid spine boards in 90 trauma patients and found that rigid spine boards cause discomfort.(5) Padding the rigid board improves patient comfort without compromising cervical spine immobilization.(99) Minimizing

the pain of immobilization may decrease voluntary movement and therefore decrease the likelihood of secondary injury.(15)

Cervical collars have been associated with elevations in intracranial pressure (ICP). Davies, prospectively analyzed ICP in a series of injured patients using the Stifneck rigid collar. ICP rose significantly ($P < 0.001$, mean 4.5 mmHg) when the collar was firmly in place. They cautioned that since head-injured patients may also require cervical spinal immobilization, it is essential that secondary insults producing raised ICP are minimized.(24) Kolb also examined changes in ICP after the application of a rigid Philadelphia collar in 20 adult patients. ICP averaged 176.8 mm H_2O initially and increased to an average of 201.5 mm H_2O after collar placement. Although the difference in ICP of 24.7 mm H_2O was statistically significant ($p = .001$), it remains uncertain that it has clinical relevance. Nonetheless, this modest increase in pressure may be important in patients who already have elevated intracranial pressure.(53) Plaisier et al in 1994 prospectively evaluated craniofacial pressure with the use of four different cervical orthoses. They found small changes in craniofacial pressure (increases) but no significant differences between the four collar types.(76)

Spinal immobilization increases the risk of pressure sores. Linares found pressure sores were associated with immobilization (patients who were not turned during the fist two hours post-injury). The development of pressure sores was not related to mode of transportation to hospital or the use of a spinal board and sandbags during transportation.(57) Mawson et al prospectively assessed the development of pressure ulcers in 39 spinal cord-injured patients who were immobilized immediately after injury. The length of time on a rigid spine board was significantly associated with the development of decubitus ulcers within 8 days of injury ($P = 0.01$).(60) Rodgers et al reported a marginal mandibular nerve palsy due to compression by a hard collar.

The palsy resolved uneventfully during the next two days.(81) Blaylock et al found that prolonged cervical spinal immobilization may result in pressure ulcers.(8) Improved skin care (keeping the skin dry), proper fitting (avoid excessive tissue pressure) and the appropriate choice of collars (those that do not trap moisture and do not exert significant tissue pressure) can reduce this risk.(7,8)

Cervical spinal immobilization may also increase the risk of aspiration and may limit respiratory function. Bauer et al, examined the effect of the Zee Extrication Device and the long spinal board on pulmonary function. They tested pulmonary function in 15 healthy, non-smoking men using forced vital capacity (FVC), forced expiratory volume in one second (FEV1), the ratio FEV1:FVC, and forced mid-expiratory flow (FEF 25%-75%). They found a significant difference ($P < .05$) between pre-strapping and post-strapping values for three of the four functions tested when on the long spinal board. Similarly significant differences were found for three of the four parameters using the Zee Extrication Device. These differences reflect a marked pulmonary restrictive effect of appropriately applied entire body spinal immobilization devices.

Totten et al, evaluated the effect of whole-body spinal immobilization on respiration in 39 adults. Respiratory function was measured at baseline, once immobilized with a Philadelphia collar on a rigid backboard, and when immobilized on a Scandinavian vacuum mattress with a vacuum collar. The comfort levels of each of the two methods were assessed on a visual analog scale. Both immobilization methods restricted respiration by an average of 15%. The effects were similar under the two methods, although the FEV1 was lower on the vacuum mattress. The vacuum mattress was significantly more comfortable than the wooden backboard.(93)

In conclusion, cervical spine immobilization devices are generally effective at limiting cervical spinal motion, but may be associated with important but usually modest morbidity.

Cervical spinal immobilization devices should be used to achieve the goals of safe extrication and transport yet should be removed as soon as it is safe to do so.

SUMMARY

Spinal immobilization can reduce untoward movement of the cervical spine and can reduce the likelihood of neurological deterioration in patients with unstable cervical spinal injuries following trauma. Immobilization of the entire spinal column is necessary in these patients until a spinal column injury (or multiple injuries) or a spinal cord injury has been excluded or until appropriate treatment has been initiated. While not supported by Class I or Class II medical evidence, this effective, time-tested practice is based on anatomic and mechanical considerations in attempt to prevent spinal cord injury and is supported by years of cumulative trauma and triage clinical experience.

It is unclear whether the spines of all trauma victims must be immobilized during pre-hospital transport. Many patients do not have spinal injuries and therefore do not require such intervention. The development of specific selection criteria for those patients for whom immobilization is indicated remains an area of investigation.

The variety of techniques employed and the lack of definitive evidence to advocate a uniform device for spinal immobilization, make immobilization technique and device recommendations difficult. It appears that a combination of rigid cervical collar with supportive blocks on a rigid backboard with straps is effective at achieving safe, effective spinal immobilization for transport. The longstanding practice of attempted cervical spinal immobilization using sandbags and tape alone is not recommended.

Cervical spine immobilization devices are effective but can result in patient morbidity. Spinal immobilization devices should be used to achieve the goals of spinal stability for safe extrication and transport. They should be removed as soon as definitive evaluation is accomplished and/or definitive management is initiated.

KEY ISSUES FOR FUTURE INVESTIGATION

The optimal device for immobilization of the cervical spine following traumatic vertebral injury should be studied in a prospective fashion.

A reliable in-field triage protocol to be applied by EMS personnel for patients with potential cervical spine injuries following trauma needs to be developed.

EVIDENTIARY TABLES

First Author Reference	Description of Study	Data Class	Conclusions
Markenson, *Pre-Hospital Emerg Care* 1999	An evaluation of the Kendrick extrication device for pediatric spinal immobilization.	Class III	KED provides excellent static and dynamic immobilization.
Perry, *Spine*, 1999	A experimental evaluation of 3 immobilization devices compared during simulated vehicle motion Neck motion was judged by 3 physicians.	Class III	Substantial amounts of head motion can occur during simulated vehicle motion regardless of the method of immobilization Movement of trunk can have equal effect as head motion on motion across the neck.
Bauer, *Ann Emerg Med* 1998	A study of the effect of spinal immobilization devices on pulmonary function in 15 men	Class III	Significant restriction of pulmonary function may result from spinal immobilization.
Mawson, *Am J Phys Med Rehabil* 1998	A prospective study to determine the association between immobilization and pressure ulcers in 39 SCI patients.	Class III	Time spent on backboard is significantly associated with pressure ulcers developing within 8 days.
Hauswald et al, *Academic Emerg Med* 1998	5-year retrospective chart review of patients with acute traumatic SCI from 2 centers. None of the 120 patients at the University of Malaya had spinal immobilization with orthotic devices during transport. All 334 patients at the University of New Mexico did. The hospitals were comparable. Neurological injuries were assigned to 2 categories, disabling or not disabling, by 2 blinded physicians. Data were analyzed using multivariate logistic regression. There was less neurological disability in the Malaysian patients (OR 2.03; 95% CI 1.03-3.99; p = 0.04). Results were similar when the analysis was limited to patients with cervical injuries (OR 1.52; 95% CI 0.64-3.62; p = 0.34).	Class III	Out-of-hospital immobilization has little effect on neurological outcome in patients with blunt spinal injuries. The association between spinal column movement and the potential for SCI remains unclear.
Blaylock, *Ostomy Wound Management* 1996	A prospective study to determine the association between immobilization and pressure ulcers in 32 SCI patients.	Class III	Pressure sores developed mostly in patients who were turned after three hours. Most of those without sores were turned less than two hours after immobilization.
Johnson, *Am J Emerg Med* 1996	Measured immobilization and comfort on 10-point scale. The vacuum splint was compared with backboard.	Class III	Vacuum splints are more comfortable and faster to apply than backboards and provide a similar degree of immobilization. Vacuum splints not rigid enough for extrication and are more expensive.

First Author Reference	Description of Study	Data Class	Conclusions
Rodgers, *J Orthop Trauma* 1995	Case report of marginal mandibular nerve palsy due to compression by a cervical hard collar	Class III	The collar was removed; the palsy resolved uneventfully during the next 2 days.
Chan, *Ann Emerg Med* 1994	A prospective study of the effects of spinal immobilization on pain and discomfort in 21 volunteers after 30-minutes. All subjects developed pain.	Class III	Standard spinal immobilization may be a cause of pain in an otherwise healthy subject.
Liew, *ANZ Journal of Surgery* 1994	Two case reports of significant occipital pressure ulceration associated with the use of hard cervical collar.	Class III	Pressure ulcers may occur with the use of hard cervical collars.
Mazolewski, *Ann Emerg Med* 1994	A study to test the effectiveness of strapping techniques in reducing lateral motion on a backboard in laboratory in 19 adults.	Class III	Strapping should be added to the torso to reduce lateral motion on a backboard.
Plaisier, *J Trauma Inj Inf Crit Care* 1994	A prospective evaluation of craniofacial pressure of four different cervical orthoses in 20 adults. Pressure was measured at the occiput, mandible, and chin. Opinions on comfort were also collected.	Class III	The Newport or Miami J have favorable skin pressure patterns and superior patient comfort.
Raphael, 1994	A randomized, single-blind, crossover study of 9 patients scheduled for elective spinal anesthesia the cerebrospinal fluid pressure in the lumbar subarachnoid space was measured with and without a 'Stifneck' cervical collar applied.	Class III	There was a significant elevation of cerebrospinal fluid pressure in seven of the patients studied when the cervical collar was applied ($p < 0.01$).
Chandler, *Ann Emerg Med* 1992	A comparison of the rigid cervical extrication collar with Ammerman halo orthosis in 20 men.	Class III	Ammerman halo orthosis and spine board provided significantly better immobilization, equivalent to halo vest.
Rosen, *Ann Emerg Med* 1992	A comparison of 4 cervical collars In 15 adult volunteers, by goniometry.	Class III	Vacuum splint cervical collar restricted range of motion of the cervical spine most effectively.
Schafermeyer, 1991	A study to assess the restrictive effects of two spinal immobilization strapping techniques on the respiratory capacity of 51 children.	Class III	Spinal immobilization significantly reduced respiratory capacity as measured by FVC in healthy patients 6 to 15 years old. There is no significant benefit of one strapping technique over the other.
Schriger, *Ann Emerg Med* 1991	A study comparing the flat backboard with occipital padding in achieving neutral position in 100 healthy volunteers.	Class III	Occipital padding places the cervical spine in more neutral alignment

First Author Reference	Description of Study	Data Class	Conclusions
Cohen, *Paraplegia*, 1990	A study analyzing the Russell Extrication device (RED) in 64 patients.	Class III	RED an effective spinal immobilization device with advantages over currently available devices.
Barney, *Ann Emerg Med,* 1989	Evaluated pain and discomfort during immobilization on rigid spine boards in 90 patients.	Class III	Spine boards may cause discomfort.
Toscano, 1988	Prevention of neurological deterioration before admission to hospital Retrospective review of 123 patients, 32 of 123 sustained major neurological deterioration from injury to admission	Class III	Appropriate handling of patients with spinal injury after trauma can reduce major neurological deterioration due to pathological motion of vertebral column.
Graziano, *Ann Emerg Med,* 1987	A radiographic comparison of pre-hospital cervical immobilization methods with the short board in 45 volunteers	Class III	The SBT proved to be significantly better ($P < .05$)
Linares, *Orthopedics,* 1987	A study of 32 SCI patients to determine whether pressure sores are associated with prolonged immobilization.	Class III	There is a strong association between 1-2 hrs of immobilization and the development of pressure sores.
McGuire, *Spine*, 1987	A radiographic evaluation of motion of the thoracolumbar spine in a cadaver with an unstable thoracolumbar spine, and a patient with a T12-L1 fracture dislocation.	Class III	Extreme motion at an unstable thoracolumbar spine segment can occur during the logroll maneuver The backboard and the Scoop stretcher offered adequate stabilization for thoracolumbar spine instability.
McCabe, *Ann Emerg Med,* 1986	A radiographic comparison of the 4 cervical collars in 7 adults.	Class III	Polyethylene - 1 provided most restriction in flexion.
Cline, *J Trauma,* 1985	A radiographic comparison of 7 methods of cervical immobilization in 97 adults.	Class III	The short-board technique appeared to be superior to all the three collars studied. The collars provided no augmentation of immobilization over that provided by the short board alone.

First Author Reference	Description of Study	Data Class	Conclusions
Podolsky, *J Trauma-Infection and Critical Care,* 1983	Static trial using goniometry comparing soft collar, hard collar, extrication collar, Philadelphia collar, bilateral sandbags and tape, and the combination of sandbags, tape and the Philadelphia collar in 25 normal adult volunteers.	Class III	Hard foam and plastic collars superior to soft collars Sandbags and tape in combination with a rigid cervical collar was the best means of those evaluated to limit cervical spine motion. The addition of a Philadelphia collar was significantly more effective in reducing neck extension ($p<0.01$), from 15 degrees to 7.4 degrees, a change of 49.3%. The combination of sandbags and tape alone does not allow sufficient restriction of extension.

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