[ Athletic Training ]

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# Cervical Spine Alignment During On-Field Management of Potential Catastrophic Spine Injuries

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**Context:** When cervical spine injuries are suspected, the cervical spine should be immobilized in a neutral position and neck motion controlled in preparation for transport to an emergency facility. Protocols for emergency transport utilizing common devices (cervical collars) and methods (transfer techniques) during these procedures are not entirely evidence based.

**Evidence Acquisition:** The medical literature search covered the time period of January 1966 to June 2008 using the following keywords, either alone or in combination: extrication collars, cervical collars, spine orthoses, spinal immobilization, spine board, spinal board, transfer techniques, and back board. Biomedical databases searched included Medline, Web of Science, and Cumulative Index to Nursing and Allied Health Literature (CINAHL [1982 to 2008]). The reference lists of all trials identified were also searched for additional trials.

**Methods:** Only trials that directly compared the efficacy or safety of transfer methods and/or immobilization devices were included. Studies that measured voluntary head movement after the fitting of the cervical orthoses and those that did not evaluate motion across individual spinal segments were not included.

**Results:** A lift-and-slide transfer method with a full body immobilization device creates less motion than a log-roll maneuver. Extrication-type cervical immobilization collars are limited in their ability to control neck motion in the injured cadaveric model.

**Conclusion:** Allied health professionals responsible for the management of the cervical spine–injured patient should become familiar with and employ a lift-and-slide transfer technique in appropriate situations and should not rely exclusively on extrication-type collars to immobilize the neck.

**Keywords:** emergency care; spine injury; immobilization

Most cervical spine injuries since 2000 have occurred in individuals between 16 and 30 years of age.[25] This age range represents the majority of the population that is involved in sporting and recreational activities. In the United States, the sport associated with the highest number of catastrophic cervical spine injuries is American football, but catastrophic spine injuries do occur in many other sports, as reported by the National Center for Catastrophic Sport Injury Research.[22] In fact, while football is associated with the greatest number of catastrophic cervical spine injuries for all sports, the incidence of injury per 100 000 participants is higher in both gymnastics and ice hockey.[22]

A catastrophic cervical spine injury is defined by Banerjee et al as "a structural distortion of the cervical spinal column associated with actual or potential damage to the spinal cord."[1] Catastrophic cervical spine injuries in sports are troubling because of the potential for permanent loss of neural function (ie, hemiplegia, quadriplegia) or even a fatal outcome. Therefore, careful management of potentially catastrophic spinal injuries is critical because of the recognized risk of neurologic deterioration during or after the acute management process.[19,31] In the out-of-hospital setting, during acute management of such injuries, the cervical spine should be immobilized in a neutral position in preparation for transport to an emergency facility, and head/neck

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motion should be limited as much as possible.[2,18] Unfortunately, many of the procedures undertaken during the acute management of an injured athlete have the potential to create motion at the injury site.

The purpose of this review is to critically analyze the literature that has investigated head/neck motion during cervical immobilization and transfer techniques associated with the management of the acute, cervical spine–injured athlete. The specific question posed is: To what extent do cervical collars and transfer techniques restrict or cause head/neck motion?

## THE NEUTRAL CERVICAL SPINE

Current recommendations for the acute treatment of the cervical spine–injured athlete are to immobilize the head and neck in neutral alignment prior to transfer to an emergency facility and to minimize the motion that occurs throughout this process.[7,18] A cervical spine that is positioned and maintained in neutral alignment should preserve the space within the spinal canal that normally surrounds the spinal cord.[5,23,24,29,30] Deviations from neutral alignment can decrease the diameter of the spinal canal and the space available for the spinal cord.[5,24] Once the spinal canal is compromised, compression of the cord can ensue, which can ultimately impair spinal cord function.[4,13] Compression of the spinal cord interrupts somatosensory-evoked potentials[4,13] and decreases spinal cord blood flow,[16,28] which in turn lead to deleterious histologic and biochemical changes that ultimately lead to tissue necrosis.[28] Animal-based research suggests that increasing levels and periods of cord compression are associated with decreases in neurologic recovery.[4,13,16]

Research has been performed to identify the relationship between cervical sagittal canal diameter and neurologic injury outcome in injured patients. Eismont et al[14] retrospectively reviewed the medical records of 98 patients who had sustained closed cervical spine fractures or dislocations. The results revealed a significant correlation between sagittal canal diameter and the degree of neurologic deficit present. In general, the larger the diameter of the spinal canal, the less likely the patient was to suffer a neurologic deficit. More recently, Kang et al[17] retrospectively analyzed the records and radiographs of 288 patients over a 30-year period who had sustained a cervical fracture or dislocation and also identified a significant association between the space available for the cord at the level of injury and the severity of neurologic deficit. Patients who had a significantly narrower sagittal canal diameter and less space available for the spinal cord had a more severe injury.[17]

This evidence supports the argument that the optimal position for the spinal cord is the neutral position.[14,29,30] This implies that if at the time of injury, the athlete's head and neck are out of alignment, the cervical spine should be realigned to neutral during the emergency management process,[6,7] a recommendation supported by the National Athletic Trainer's Association's Inter-Association Task Force for the Care of the Spine-Injured Athlete.[18] If acute realignment of the cervical spine is necessary, this should be done gradually while observing the patient for any changes in neurologic status. In some cases, realignment of the cervical spine occurs during a log-roll maneuver in the prone athlete. If changes in neurologic status occur mid-roll, it is difficult to coordinate a change to the roll maneuver with multiple people involved in the transfer. Therefore, it may be best to perform the realignment after log-rolling the prone victim to a supine position. Three general contraindications exist to moving the cervical spine to neutral: (1) the movement causes or increases pain, neurologic symptoms, or muscle spasm compromising the airway[8]; (2) resistance to movement is encountered[15]; or (3) the patient expresses apprehension.

## STABILIZATION AND TRANSFER

### Cervical Collars

In the prehospital stages of injury, cervical collars are often used as immobilization devices along with spine boards and head strips. Numerous investigations have assessed the restraining capacity of these devices. Ideally, an extrication-type collar minimizes the spinal motion across the unstable spinal segment. Thus, to determine the effectiveness of extrication collars, it is necessary to assess the motion of unstable cervical spine segments, not just head-to-trunk motion. The kinematics of the spine become altered after injury and can only be evaluated in that condition.

There were 129 eligible studies in the literature. Nineteen articles addressed the critical issue: range of motion across unstable cervical spine segments with immobilization devices. Trials that examined the capacity of collars to restrict active range of motion were not included. Four randomized, controlled, crossover trials and case reports comparing various types of cervical orthoses in cadavers were identified.[3,9,20,26]

McGuire et al[20] investigated a posterior ligamentous injury at the C4-C5 spinal segment in 3 cadavers. Cervical rotation and translation in the sagittal plane were assessed at the unstable segment. A 5-pound flexion load was generated using an overhead pulley system. Three cervical orthoses, as well as a collar that was attached to a halo device, were tested. All 3 cervical orthoses were comparable in their ability to limit translation across the unstable segment. Application of the flexion force caused angular changes that averaged between 13.4° and 15.4° in the various collars. In contrast, the cervical collar with halo attachment was able to minimize both rotation and translation motion.[20] Unfortunately, the application of a noninvasive halo device that uses hook and loop fasteners with a suspected spine-injured patient in the prehospital setting might not be practical.

In a study by Richter et al,[26] a similar design was used to compare the effectiveness of a soft collar, cervical extrication collar, cervical collar with thoracic extensions, and halo device to restrict motion across unstable cervical segments (C1-C2 and C2-C3). With the exception of the soft collar, all devices (including the extrication-type collar) were able to restrict motion by at least 54%. The halo vest provided the greatest control of movement by limiting spinal motion to under 2°, including rotation, which is very difficult to control.[26]

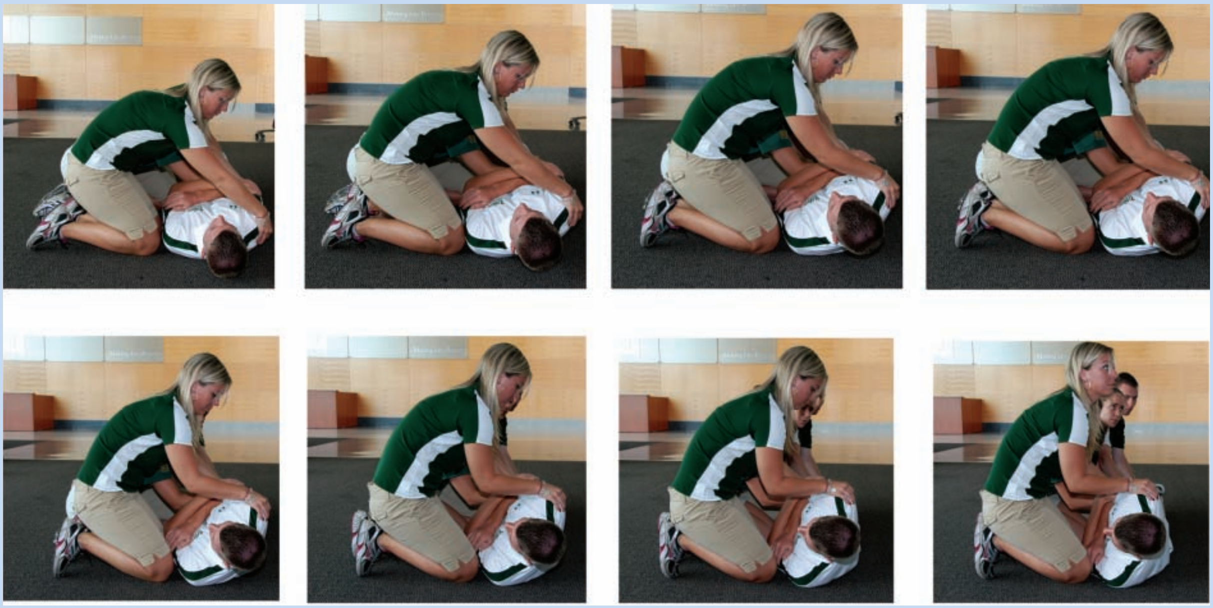

Figure 1. The log roll. The rescuers are performing a log roll on a supine athlete. Observe the path the head travels during the execution of the log roll, starting from the upper left image and ending at the lower right. The rescuer normally positioned at the head is removed for illustrative purposes.

In a cadaveric model with an unstable spine and an externally applied flexion load, Bednar[3] tested the effectiveness of soft, semirigid, and hard cervical collars.[3] For testing, the heads and necks of the cadavers were placed in a gravity-dependent position by elevating the torso of the prone cadaver such that the weight of the head was unsupported. Surprisingly, pathologic displacement was not restricted under gravity load in any of the trials. Bednar[3] concluded that cervical collars do not limit motion in the unstable cervical spine (between C4 and C6) and cited a "levering" phenomenon, in which motion produced across the unstable spinal segment actually increased after collar application.[3]

The last of the 4 studies attempted to identify a cervical extrication collar that could restrict spinal motion while providing in-line stabilization during transfer of a patient to a spine board. Del Rossi et al[9] tested the extrication collars on 5 cadavers with severe instability at C5-C6. The reduction in segmental spine motion with each of the collars was insignificant (with the greatest reduction in motion being less than 3°).

## Spine Board Transfer Techniques

To achieve full cervical spine immobilization during on-field management of a head/neck injury, medical personnel must transfer and secure the patient to a full-body immobilization device; typically a spine board. The task of transferring a patient onto a spine board can prove challenging because the head, neck, and trunk must be moved together as a unit. To facilitate this task, medical personnel rely on specifically designed manual techniques and/or mechanical devices. Perhaps the most frequently used manual transfer technique is the log-roll (LR) maneuver (Figure 1). This transfer technique involves rotating the injured patient to the side-lying position to allow a spine board to be positioned beneath the individual. An alternative to the LR is a lift-and-slide (LS) procedure. This procedure involves raising the patient off the ground in the neutral position to permit spine-board placement (Figure 2). In addition to the LS technique, there are other iterations of this lifting procedure, such as the 6-plus–person lift (6+).[18] By using these techniques properly, medical personnel can provide continuous, inline stabilization of the head and neck in the neutral position while transferring the spine-injured patient onto a spine board.

A review of the literature identified 42 potentially eligible articles; 19 were retrieved for a more detailed analysis, but only 5 were included that directly compared the efficacy or safety of transfer methods. Randomized, controlled, crossover trials (4) and case reports (1) comparing various patient transfer techniques and/or immobilization devices on healthy volunteers, injured patients, or cadaveric specimens were included.

Research of manual transfer techniques first appeared in the literature in 1983. The initial article reported that the LR technique was not adequate for patients with thoracolumbar injuries because considerable motion of unstable segments was likely to occur during the transfer process.[21] It was not until 2003 that an investigation examined cervical spine motion during execution of these emergency procedures.[11] This study was conducted on healthy individuals and revealed that the LR resulted in significantly greater lateral-flexion motion

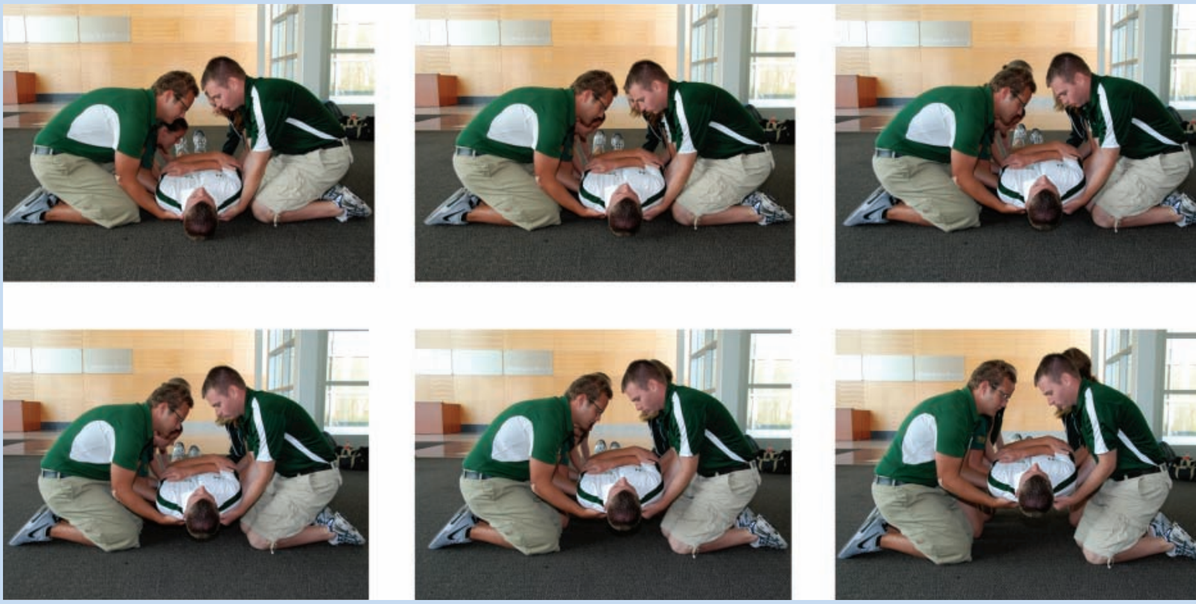

Figure 2. The 6-plus–person lift. The rescuers are performing a lift maneuver on a supine athlete. Observe the path the head travels during the execution of the lift, starting from the upper left image and ending at the lower right. The rescuer normally positioned at the head is removed for illustrative purposes.

(approximately 8° more) and axial rotation (approximately 18° more) of the head as compared with the LS.[11]

Del Rossi et al[10] performed a cadaver study with an unstable C5-C6 spinal segment. Flexion-extension motion was assessed during the transfer processes. The LR and LS were equally effective at restricting sagittal plane motion to less than 4°. However, when transverse and frontal plane motions were examined in subsequent research investigations on cadavers with unstable cervical spines, researchers identified a difference between the LR and lifting techniques. Del Rossi et al[12] reported that lateral flexion, axial rotation, and medial-lateral translation were best controlled using the LS and 6+ as compared to the LR. Performing the LR resulted in approximately 4° more axial rotation and lateral flexion and 4 mm of medial-lateral translation between the unstable vertebrae.

The tendency to generate more axial rotation and lateral flexion may be due to the complex coordination required to execute the LR as compared to either the 6+ or LS. During the LR, the body never leaves the ground as the patient is rolled to the side-lying position (Figure 1). To keep the cervical spine neutral, the head must be lifted from the ground and follow a horizontal arc of motion. Deviations from this curvilinear path may result in malalignment between the head and body, causing torsional displacement of unstable cervical spine segments. In contrast, providing head and neck stabilization during the 6+ and LS techniques requires lifting the head and moving it in a linear path with the rest of the body (Figure 2). This head and torso maneuver is easier to coordinate, resulting in less torsional deviations in the cervical spine.

Additionally, the LR maneuver is likely to alter the slope of the thoracolumbar spine, if girth proportion differences exist along the length of the body.[27] Differences in pelvic and thoracic width may be of no consequence when the patient is supine, but may be a factor when the patient is rolled to the side-lying position. If this sloping of the spine is not anticipated by the person stabilizing the head, lateral deviation of the cervical spine could result (Figure 3). For these reasons, the LS and 6+ are the recommended methods of transfer for the supine injured athlete onto a full body immobilization device.

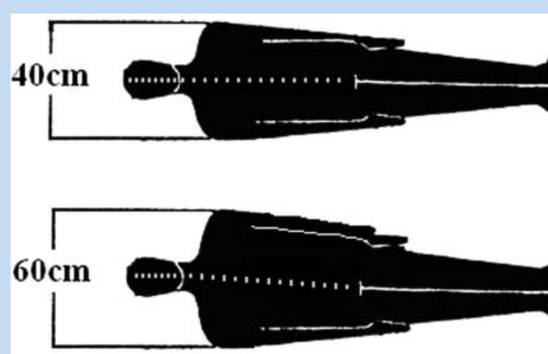


Figure 3. Girth proportion. Note the relative difference in width between the shoulders and pelvic girdle between the hypothetical injured athletes in the side-lying position. The larger shoulder width in the athlete on the bottom increases the slope (represented by the dashed line) between the shoulders and pelvic girdle.

# Clinical Recommendations

**SORT: Strength of Recommendation Taxonomy**
**A:** consistent, good-quality patient-oriented evidence
**B:** inconsistent or limited-quality patient-oriented evidence
**C:** consensus, disease-oriented evidence, usual practice, expert opinion, or case series

| Clinical Recommendation | SORT Evidence Rating |
|---|---|
| When a cervical spine injury is suspected, the spine should be immobilized in the neutral position. The neutral position can reduce spinal cord compromise and may facilitate airway management and application of immobilization devices. A small amount of spinal motion is likely to occur with most emergency interventions. Primary responders to potential cervical spine–injured patients should become familiar with the various techniques and devices that are available to them. | B |
| If acute realignment of the cervical spine is necessary, this should be done gradually, while observing the patient for any changes in neurologic status. In some cases, realignment of the cervical spine occurs during an LR maneuver in the prone athlete, but if changes in neurologic status occur mid-roll, it is difficult to perform the roll maneuver with multiple people involved in the transfer. Therefore, it may be best to perform the realignment after log-rolling the prone victim to a supine position. | C |
| Three general contraindications exist to moving the cervical spine to neutral: (1) the movement causes or increases pain, neurologic symptoms, or muscle spasm compromising the airway[8]; (2) resistance to movement is encountered[15]; or (3) the patient expresses apprehension. | B |
| Unfortunately, the degree of motion necessary to compromise neural tissue is unknown and probably varies. Therefore, medical personnel should practice making decisions regarding transfer technique and device utilization based upon the presenting circumstances: personnel, the expertise of the rescue team, injury position, degree of urgency, and athletic equipment obstacles. | B |

For more information about the SORT evidence rating system, see www.aafp.org/afpsort.xml and Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. *Am Fam Physician.* 2004;69:549-557.

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