The effectiveness of extrication collars tested during the execution of spine-board transfer techniques

Gianluca Del Rossi, PhD\textsuperscript{a,}\textsuperscript{*}, Tim P. Heffernan, BS\textsuperscript{b}, MaryBeth Horodyski, EdD\textsuperscript{b}, Glenn R. Rechtine, MD\textsuperscript{b}

\textsuperscript{a}Department of Exercise and Sport Sciences, School of Education, 312E Merrick Building, PO Box 248065, University of Miami, Coral Gables, FL 33124-2040, USA
\textsuperscript{b}Department of Orthopaedics and Rehabilitation, Box 100246, University of Florida, Gainesville, FL 32610-0246, USA

Received 8 September 2003; accepted 7 June 2004

Abstract

BACKGROUND CONTEXT: In the prehospital stages of emergency care, cervical collars are (supposedly) used to aid rescuers in maintaining in-line stabilization of the spinal column as patients with potential or actual injuries are shifted onto a spine board to achieve full spinal immobilization. Unfortunately, not a single study has examined the effectiveness of cervical collars to control motion during the execution of spine-board transfer techniques.

PURPOSE: To evaluate the controlling effect of three cervical collars during the execution of spine-board transfer techniques.

STUDY DESIGN: This was a repeated measures investigation in which a cadaveric model was used to test the effectiveness of the Ambu (Ambu, Inc., Linthicum, MD), Aspen (Aspen Medical Products, Inc., Long Beach, CA) and Miami J (Jerome Medical, Moorestown, NJ) collars during the execution of the log-roll (LR) maneuver and the lift-and-slide (LS) technique.

METHODS: Six medical professionals executed the LR and the LS on five cadavers. An electromagnetic tracking device was used to capture angular movements generated at the C5–C6 vertebral segment during the execution of both transfer techniques. The types of motion that were analyzed in this study were flexion-extension, lateral flexion and axial rotation motion. To test the three cervical collars, an experimental lesion (ie, a complete segmental instability) was created at the aforementioned spinal level of the cadavers and sensors from the electromagnetic tracking device were affixed to the specified vertebrae to record the motion generated at the site of the lesion.

RESULTS: Statistical tests did not reveal a significant interaction between the independent variables of this study (ie, transfer technique and collar type), lending no support to the notion that there may be a combination of collar and transfer technique that could theoretically offer added protection to the patient. Although there was a decrease in the amount of motion generated in every one of the planes of motion as a result of wearing each of the three collars, none of the changes that emerged proved to be significantly different. A significant difference was noted between the LR and LS techniques when the amount of lateral flexion and axial rotation motion generated with each of the procedures were compared. In both cases, execution of the LR maneuver resulted in significantly more motion.

CONCLUSIONS: The data presented here suggest that the collars tested in this study are functionally similar. It is recommended that this study be repeated with a larger sample size.

Keywords: Cervical instability; Log-roll; Lift-and-slide; Cervical immobilization collar; Extrication collar

\textsuperscript{*}Corresponding author. Department of Exercise and Sport Sciences, School of Education, 312E Merrick Building, P.O. Box 248065, University of Miami, Coral Gables, FL 33124-2040, USA. Tel.: (305) 384-3711; fax: (305) 284-3003.
E-mail address: delrossi@miami.edu (G. Del Rossi)
Introduction

To lessen the probability of generating secondary neurological injuries after cervical spine trauma, management guidelines stipulate that the entire spinal column of the injured patient be immobilized to allow for safe transport to a medical facility [1]. Thus, it is standard practice to secure injured patients to a long spine board to achieve full spinal immobilization. However, before moving a patient with a suspected or actual spinal injury, it is required that he or she be fitted with a cervical collar. In the prehospital stages of injury management, a cervical collar serves two potentially important functions: to aid rescuers in maintaining in-line stabilization during the transfer process (as the patient is shifted onto spine board) and also to enhance the effectiveness of the immobilization system that is used by the rescue team (ie, the combination of spine board, cervical collar, straps and head immobilization device).

Numerous investigations have attempted to assess the general ability of cervical collars to restrict or reduce both segmental and overall spinal motion [2–10]. However, many of the research studies that have been completed to date were designed to evaluate the ability of immobilization collars to prevent the cervical spine from moving (be it actively or passively) through large ranges of motion, or even to the extremes of motion [2–6,9,10]. Consequently, the results from such studies could not be used to establish the relative usefulness of extrication-type collars. Normally, the purpose of an extrication-type collar is to help minimize or control the (presumably) small amount of spinal motion that may be unintentionally generated during the prehospital stages of emergency care. Extrication collars are thus more aptly studied if the experimental protocol that is developed includes an external loading condition that results in the production of spinal motion that approximates the quality and quantity of motion generated in real-life situations.

Seemingly, the most appropriate study performed to date was by McGuire et al. [7], who generated a relatively small flexion force to test the ability of four collars to control the amount of motion produced between unstable cervical spine segments. After surgically creating an experimental lesion at the C4–C5 level of three cadavers, McGuire et al. [7] measured the amount of sagittal rotation and translation that resulted immediately after collar placement and during the application of a 5-pound flexion force. The reasons for using a 5-pound load were never specified by the authors. In any case, close examination of the results revealed that the investigational load of 5 pounds resulted in upwards of 26 degrees of flexion in at least one trial. Given such a sizable shift in spinal segment position, it would therefore seem that the flexion moment created by a 5-pound weight was not particularly suitable for testing extrication-type collars.

In our view, an investigation capable of assessing the efficacy of cervical collars using an experimental protocol that takes into consideration the actual function of extrication collars was still necessary. Thus, the purpose of this investigation was to evaluate the ability of three cervical collars to restrict or control the motion generated across an unstable segment of the lower cervical spine during the execution of spine-board transfer techniques.

Materials and methods

Participants

For this study, we required that six participants join forces to execute the log-roll (LR) and the lift-and-slide (LS) transfer techniques. The group recruited to assist with this study consisted of three doctors, two certified athletic trainers and a nurse (for a total of two women and four men). In addition, we relied on an orthotist to help fit all collars. As is the case with most research studies involving human subjects, all participants of this study were required to complete an informed consent form approved by the institutional review board of the university.

Experimental lesion

The effectiveness of each cervical collar was evaluated by measuring the spinal motion produced at the site of an experimental lesion. The purpose of generating a lesion was to be able to reproduce or simulate one of several possible injury conditions. For this particular study, a complete segmental injury (resulting in a global instability) was surgically created on five cadavers (2 men, 3 women). The mean age and weight of the cadavers was 78.8±14.64 years and 66.68±15.10 kg, respectively. To standardize the injury condition, a spine surgeon (GRR) generated the experimental lesion at the C5–C6 spinal segment of each cadaver. The lesion was created by excising the supraspinous and interspinous ligaments, the ligamentum flavum, the spinal cord, the facet capsules, the posterior longitudinal ligament, the intervertebral disc and the anterior longitudinal ligament.

Equipment

A Fastrak motion analysis device (Polhemus, Inc., Colchester, VT) was used to quantify the motion generated between the fifth and sixth cervical vertebrae. The Fastrak device is a tracking instrument that uses electromagnetic fields to establish the three-dimensional position and orientation of its sensors. Pilot testing revealed this device to be both accurate and reliable. To collect motion data at the C5–C6 segment, a sensor was positioned on the anterior surface of each vertebral body. These two sensors recorded the amount of flexion-extension, lateral flexion and axial rotation motion that was produced across the spinal segment. In order to secure the sensors onto the chosen landmarks, they were connected to small fasteners that were affixed to the vertebral bodies using carbon-fiber rods.
Treatment conditions

There were four treatment conditions tested in this investigation: a control condition (no collar) and three collar conditions. The three collars tested in this study were the Ambu (Ambu, Inc., Linthicum, MD), the Aspen (Aspen Medical Products, Inc., Long Beach, CA) and the Miami J (Jerome Medical, Moorestown, NJ) (Fig. 1). In all cases, collars were individually sized and then fitted on each of the cadavers by a single technician (orthotist).

Experimental procedure

At the very beginning of the study, participants were asked to complete a brief familiarization session so as to become acquainted with the study protocol. The actual testing of collars began after this familiarization session. For all test trials, cadavers were positioned supine on the ground. The control condition (no collar) was the first to be tested, followed in random order by the three collar conditions. The participants of this study were asked to complete two trials of the LR maneuver and two trials of the LS technique for each of the treatment conditions and with each of the cadavers. If at the completion of any trial the cadaver was not centered on the spine board, appropriate adjustments were made to ensure correct placement or positioning. Because of the amount of lifting involved with this study, there was some concern that the participants may become fatigued. To avoid the effects of fatigue, this investigation was completed over the course of 2 days. That is, three cadavers were tested on the first day and the remaining two cadavers on the second day.

Statistical analysis

Three dependent variables were considered in this study: flexion-extension, lateral flexion and axial rotation motion. These measures were dependent on two (independent) variables: technique and treatment condition. To analyze the collected data, we calculated a 2x4 (technique by treatment condition) analysis of variance with repeated measures for each of the three dependent variables. The level of significance for all statistical tests was set, a priori, at α<.05. Simple interaction effects and post hoc tests (using Tukey’s Honestly Significant Difference procedure) were calculated when necessary.

Results

The amount of flexion-extension, lateral flexion and axial rotation motion generated at the C5–C6 segment with each of the four treatments are presented in Tables 1 to 3. Statistical analyses of all motion data revealed no significant interactions between independent variables. The analyses of the main effects revealed that there were no significant differences between any of the collar treatments, regardless of the motion. However, a significant main effect for technique was noted with both lateral flexion (F[1,4]=12.23, p<.05) and axial rotation (F[1,4]=375.60, p<.0001) motion. In both cases, the motion generated with the execution of the LR maneuver was significantly more than the motion produced with the LS technique.

Discussion

To verify that the Ambu, Aspen and Miami J collars could serve as extrication orthoses, we created an artificial situation (ie, simulated a severe spinal injury in a group of cadavers) to properly assess the amount of spinal motion that each collar would permit during the execution of the LR maneuver and the LS technique. Given that the transfer methods performed in this investigation were considerably dissimilar, it was completely feasible for the structural design of one collar to match up well with one of the transfer techniques but not the other. Compatibility between any one of the collars with either the LR maneuver or LS technique would mean that more protection could be offered to the patient if such a combination were to be used. Regrettably, of the six possible combinations of orthoses and transfer techniques, no such favorable combination was identified.

Instead, at first glance, all of the collars seemed to offer some protection to the patient, regardless of the transfer technique that they were used in combination with. Unfortunately, the reduction in segmental spine motion that resulted
with each of the collars was small and, in fact, did not differ significantly from the spinal motion that was generated without a collar (ie, the control condition). Naturally, this was a totally unexpected outcome and may conceivably have some unwarranted implications.

Obviously, if a cervical collar does not offer a patient any added protection, the tendency would be to lessen the importance placed on the use of cervical collars and perhaps discontinue its use all together. We, however, are extremely reluctant to discount the role or effectiveness of cervical collars. Our reluctance stems mostly from our belief that the benefits of using an extrication-type collar likely do not become apparent until a disproportionate amount of motion is generated. If the assumption is that a cervical orthoses has a certain amount of slack that must be taken up before it can offer resistance to extrinsically produced motion, it follows that a rescue team that can keep spinal motion to a minimum may not necessarily benefit from using a cervical collar. However, if the amount of cervical spine motion were to drastically increase, then presumably extrication collars could offer some degree of resistance to motion and thus help to protect the patient from the creation of secondary neurologic injury. Therefore, we are proposing that a cervical collar continue to be used because it can serve as a backup system to the manual stabilization offered by the rescue team.

With regard to transfer techniques, it became evident that the LR maneuver was not the best method for shifting cervical spine–injured patients onto a spine board. Statistical tests performed on our data revealed that the execution of the LR maneuver resulted in considerably more head displacement motion when compared to the LS technique. This was not the case with any of the other cervical collars. Our reluctance stems mostly from our belief that essentially the absence of muscle spasms (and thus help to protect the patient from the creation of secondary neurologic injury) allows researchers to surgically create different types of lesions anywhere along the spinal column, one cannot expect the spinal motion of a cadaver to display similarities to the motion produced by a living patient. For example, it is readily acknowledged that muscle spasms inevitably develop after spinal injury. In the living patient this muscle guarding could impact the motion produced at or about the injured spinal segment [16]. In a study using cadavers, the protective effect of muscle spasms cannot be reproduced. By consciously choosing not to accurately recreate what is understood to be the in vivo condition, one runs the risk of reporting motion data that cannot be characterized as being realistic or even possible in the living condition. In our defense, even though we failed to reproduce the effect of muscle spasms, we decided to proceed with this investigation because we believed that essentially the absence of muscle spasms (and of the protective effects offered by such muscle guarding) would allow us to create a worst-case scenario wherein the restriction to motion would be totally dependent on the skills of the rescue team and the protection offered by the extrication collars.

By developing an experimental protocol in which only one type of injury is created and then tested across a single level of the spine, one effectively limits the generalizability of the study results. Because the experimental injury model

### Table 1
Flexion-extension motion generated during execution of spine-board transfer techniques

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Log-roll (degrees)</th>
<th>Lift-and-slide (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No collar</td>
<td>4.93 (1.79)</td>
<td>6.39 (2.94)</td>
</tr>
<tr>
<td>Ambu</td>
<td>2.84 (1.47)</td>
<td>4.12 (3.02)</td>
</tr>
<tr>
<td>Miami J</td>
<td>3.05 (0.60)</td>
<td>3.67 (1.70)</td>
</tr>
<tr>
<td>Aspen</td>
<td>3.39 (0.75)</td>
<td>3.84 (2.29)</td>
</tr>
</tbody>
</table>

### Table 2
Lateral flexion motion generated during execution of spine-board transfer techniques

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Log-roll* (degrees)</th>
<th>Lift-and-slide* (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No collar</td>
<td>2.66 (1.22)</td>
<td>2.09 (1.09)</td>
</tr>
<tr>
<td>Ambu</td>
<td>2.27 (1.08)</td>
<td>1.27 (0.73)</td>
</tr>
<tr>
<td>Miami J</td>
<td>1.59 (0.67)</td>
<td>1.04 (0.39)</td>
</tr>
<tr>
<td>Aspen</td>
<td>1.75 (0.73)</td>
<td>1.33 (0.58)</td>
</tr>
</tbody>
</table>

* P<.05.

### Table 3
Axial rotation motion generated during execution of spine board transfer techniques

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Log-roll* (degrees)</th>
<th>Lift-and-slide* (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No collar</td>
<td>7.70 (2.97)</td>
<td>2.94 (1.84)</td>
</tr>
<tr>
<td>Ambu</td>
<td>6.14 (1.11)</td>
<td>1.84 (0.56)</td>
</tr>
<tr>
<td>Miami J</td>
<td>6.40 (1.38)</td>
<td>2.39 (1.18)</td>
</tr>
<tr>
<td>Aspen</td>
<td>7.09 (1.28)</td>
<td>2.39 (0.91)</td>
</tr>
</tbody>
</table>

* P<.05.
used in this study was extremely specific (we surgically created a complete segmental injury at the C5–C6 segment of all cadavers), it represents a small fraction of all the possible clinical conditions, and as such, the results of this study cannot be used to predict how different injuries or clinical conditions respond during the execution of spine-board transfer techniques.

Yet another limitation of this study is related to our decision to test collars with similar design characteristics. The collars that were tested in this experiment are typically classified as cervical orthoses. These types of collars are essentially designed to limit the range of motion of the cervical spine by restricting the movement of the head (on account of the collar fitting snugly against the mandible and occiput of the patient). In addition to these cervical orthoses, there are other styles or types of collars. For instance, there are collars that feature a halo device and others that incorporate thoracic extensions, both of which purportedly enhance the immobilization of the cervical spine. Although it may not always be very practical to fit a patient with a halo collar or with a cervical-thoracic orthotic in the prehospital setting, we probably could have strengthened our study by testing these types of collars. Future studies should certainly address this issue.

Lastly, we would like to comment on our sample size. Admittedly, our sample size was small, but in truth, the decision to include only five cadavers in this study was not dictated by the outcome of power analyses but by financial considerations. In any case, once the data collection was complete, we performed several power analyses that revealed the study was adequately powered in some cases but not in others. Unfortunately, a computation revealing low statistical power denotes reduced odds of actually observing a treatment effect when it occurs. An accepted method of increasing power is to increase sample size. Therefore, a study with a larger sample size could have improved the likelihood of obtaining data from which more robust or interesting conclusions could have been drawn.

In summary, the collars tested in this study were functionally similar. Moreover, the statistical analyses of our data did not reveal a significant difference between any of the collar treatments and the control condition (no collar). Notwithstanding the latter finding, we are of the opinion that when transferring a patient to a spine board, the key remains to combine the rigorous application of manual stabilization with the potential controlling effect of a cervical extrication collar. Finally, given that the calculations of statistical power were at times low, we encourage others to repeat this study making certain to include a larger sample size.

Acknowledgments

The authors would like to thank Bryan Conrad for his assistance on this project.

References