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Internal Decapitation - High Ligamentus Cervical Injury

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Foundation for Concept

The neck is particularly vulnerable to injury from motor vehicle accidents (MVAs), falls and blunt trauma. The potentially devastating consequences of secondary damage to the spine following the initial trauma include quadriplegia, respiratory device dependency, and frank death.[1,2,3,4] The initial injuries include a range of fractures and ligament, muscle, fascial, and vascular disruptions, the worst of which are the recently described "internal decapitation" injuries of the upper cervical spine.[5] The vertebrae, ligaments, muscles, tendons, fascia, skin, and other tissues of the neck, together with the head and the shoulders form a complex (head-neck-shoulder, HNS) in which all the components contribute to the integrity of this region.

Catastrophic secondary damage to the HNS complex with major neurological deterioration can occur post-primary injury in trauma victims.[4,6-8] It is estimated that up to 25% of spinal cord injuries are preventable and occur during the interval between the time of injury and admission to the hospital due to a lack of adequate spinal immobilization.[4,6-9] The exact nature of the injury is initially uncertain, and emergency medical responders traditionally have a low threshold of suspicion for injury to the HNS complex. Conventional wisdom is to follow protocols ostensibly designed to protect against further injury.

The Advanced Trauma Life Support (ATLS) protocol mandates assessing the airway, breathing, and circulation with proper manual in-line stabilization of the neck.[10] The intent is to prevent the devastating consequences associated with aggravation of an already unstable neck. Current protocols typically include placement of an extrication collar on any trauma victim suspected of an injury to the HNS complex.

Though millions of collars are applied annually to trauma victims, the actual available evidence on the effectiveness of extrication collars in preventing secondary injury to the HNS complex is limited and inconsistent. A collar may not significantly prevent potentially dangerous intervertebral motion when most of the intervertebral disc and ligamentous structures that connect the vertebrae are already damaged.[11-14]

The possibility that cervical collars can cause harmful distraction between vertebrae became a research focus after observing unmistakable head-to-neck separation associated with cervical collar application and a potential relationship to morbidity and mortality.[5] These observations raised the concern that cervical collar application and current trauma management methods in general may be contributing to some of the over 40,000 deaths from traumatic injury and the thousands of disabling spinal cord injuries that occur each year in the U.S.[15]

Goals of this Presentation

The purpose of this presentation is to demonstrate the direct mechanical effect of cervical collar application upon the HNS complex in the presence of a typical soft tissue, bone, and ligamentous dissociative injury to the upper cervical spine namely – internal decapitation injuries. This presentation focuses on the motion between the vertebrae and the occiput caused by application of a collar in the presence of an unstable cervical injury. We hypothesized that the routine application of rigid cervical collars can, in itself, create as much occipita-cervical distraction as has been observed in trauma victims who died of their injuries.

Literature Review

Many studies have provided some evidence that a cervical extrication collar can actually lead to severe complications in certain cases.[5,21-25] A critical analysis of these reports supports the concern that the application of a collar could potentiate severe damage, including a major spinal cord injury. This can occur at any level of the cervical spine, but seems to be most common at the atlanto-occipital junction or between the first and second cervical vertebrae.[26]

Concerns about the effectiveness of current spinal immobilization techniques with cervical collar application have also been raised in a multi-centered retrospective review in which trauma patients transferred to hospitals with no cervical collars fared better and had less neurological deterioration prior to hospital arrival than patients treated with collars as part of their immobilization.[38] There are several mechanisms by which a collar could compromise clinical outcomes. Undesirable side-effects of collars have already been documented, such as pressure ulcers, elevated intracranial pressures, obstructed CSF or venous flow, and difficult intubations.[23,39-41] Review of the data and images from previously published clinical studies on dissociative injuries and the results of this study provide convincing evidence that cervical extrication collar application can cause distraction between vertebrae and have the potential to cause harm.[5,21-22,42]

The statistics of mortality and morbidity in association with cervical dissociative injuries are daunting. In 2005, there were 10.7 million motor vehicle accidents (MVA) resulting in over 43,400 deaths within 30 days of the MVA (National Safety Council, Itasca, IL, Injury Facts, annual, http://www.nsc.org). The actual cause(s) of death in these accidents varies, but forensic studies documented an incidence of cervical dissociative injuries as high as 94%, and believed them to be responsible for the cause of death in approximately one-third of the cases.[48] Almost half of the cervical injuries found in a consecutive series of 100 fatal accident victims were at the craniocervical region.[19] A recent literature review concluded that approximately 8% of unconscious or obtunded trauma patients who present to the emergency department may have a major injury to the cervical spine.[1] In survivors of trauma, severe injuries to the cervical spine were found in up to 3.7% (i.e., over 1000 patients in the U.S. per day from MVAs alone).[1,2] Preventable deaths following trauma occur due to a variety of factors, including inappropriate cervical immobilization.[49]

Furthermore, over 10,000 people suffer spinal cord injuries each year in the U.S., with 36% caused by MVA. The annual aggregate direct healthcare cost is over $3 billion.[50] Cervical immobilization is used on almost 90% of patients transported to an emergency room by ambulance, and there were approximately 18 million patients transported to emergency rooms by ambulance in 2006.[51,52] Optimization of cervical stabilization and patient management protocols could benefit many. It is clear that additional, high-quality scientific evidence is needed to validate management protocols that can reduce the number of preventable deaths and spinal cord injuries. Our current data provide a proof of mechanical concept that collar application creates a distractive mechanism that effectively pushes the head away from the body. This evidence in cadavers and the same effect seen clinically while following current trauma guidelines in treatment of trauma patients adds to the body of literature indicating that cervical collar application in itself may cause devastating clinical consequences.[(5,21,22,42) (19,28,34,46,47)]

Several other investigators reported that patients with massive damage to the upper cervical spine can survive the initial injury if appropriately managed.[5,33,34] Unfortunately, the optimum management protocol has yet to be established and validated. There are hundreds of published studies addressing methods for cervical spine stabilization, but none of them were considered to be high-level scientific evidence in a recent Cochrane Review.[35] It is inherently difficult to generate randomized controlled clinical studies for scientific evidence regarding the optimum approach to protecting the HNS complex in trauma victims particularly in the pre-hospital period. It is not surprising that a recent Cochrane review noted that there are no randomized, controlled trials that can be used to determine or compare the effectiveness of approaches to stabilizing the cervical spine in trauma victims. For lack of high-quality evidence, it had to resort to summarizing some of the low-level evidence that suggests various immobilization methods can reduce head or intervertebral motion in healthy volunteers. For example, some studies that assessed the effect of cervical collar immobilization found that strapping a volunteer to a standard short board was more effective than using a cervical collar alone when immobilizing the cervical spine.[36,37]

Observations of Clinical Cases

During the past four years, a significant number of patients were seen in local trauma centers in whom their clinical neurologic status changed after involvement of trained emergency and medical personnel were involved in their care.[5] Despite following existing standards of immobilization, stabilization, and device application, high cervical cord injuries were found in patient with high cervical ligamentus disruption. These cases presented complex management and ethical problems and led to the investigations presented in this manuscript.

Human Volunteers

Following approval from appropriate human studies boards, patients, human volunteers, and fresh human cadaver research was conducted to evaluate the hypothesis that cervical collar application might lead to significant head to neck dissociative injuries (internal decapitation type injuries). During collar application technique including in-line stabilization distraction was documented at the cervical injury site in every case. The head to neck distraction distances measured for all trauma patients was outside the 95% for normal displacement as measured in asymptomatic volunteers.

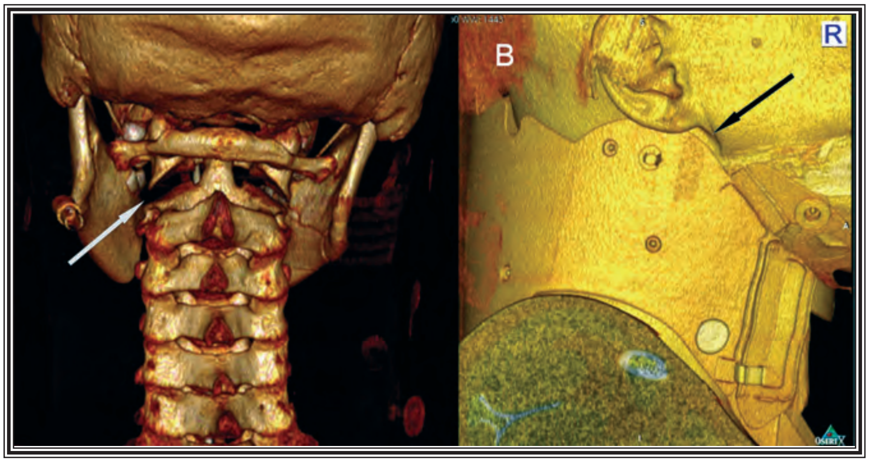
Fresh Human Cadaver Studies

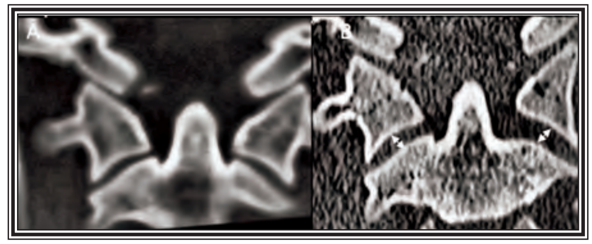
In fresh human cadaver studies, application of cervical collars caused abnormal increased separation, at the C1-C2 level in every case. Gross displacement of the cadavers head relative to the body was visually apparent and was consistent with the internal displacements observed in the CT images. Frank separation of the head and upper neck from the rest of the body was seen in every cadaver after a cervical collar was applied. This emphasizes that collar application includes a distractive mechanism of action such that pushes the head away from the body, resulting in stretching and translation of soft-tissues, including the spinal cord and vertebral arteries. There are not enough definitive clinical data in order to determine the amount and type of motion or sustained displacement that will result in neurologic deficit, but there is little room for doubt that the measured distraction could contribute to temporary or permanent neurologic deficit, or lead to death if it occurred in a trauma victim.

In addition to the axial displacement, extension, or flexion commonly occurs with application of a collar. This is manifest in the larger magnitudes and variations in the posterior canal measurements. The anterior canal measurements made from lateral fluoroscopic images were statistically equivalent to the measurements made at the facet joints from CT or AP open-mouth radiographs. The anterior fluoroscopic measurements for asymptomatic volunteers, trauma patients, and the fluoroscopically imaged cadavers, and the CT-based facet measurements are graphically illustrated in the figures.

The magnitude of head to neck separation seen in every cadaver in the presented study with application of a cervical collar is as alarming as that seen in our clinical trauma patients.[5] Current trauma guidelines may not adequately protect against this effect in the management of trauma victims.

The amount of intervertebral motion that was measured in the group 1 cadavers was nearly identical to that measured in our trauma patients, and the magnitude is similar to that of clinical reports of upper cervical dissociative injuries.[27-31]





Theses figures demonstrate patients with OCI (occipito-cervical dissociative injuries) with and without cervical collars and how the injury is augmented and made worse by collar application since that creates distractive forces that tend to push the head away from the shoulders and results in separation between the injured intervertebral segments.

Although some of those reported patients survived, the majority of the injuries resulted in death or disability.[27-31] Harris, et al. noted that all but one of the 23 patients who died of neck injuries had grossly abnormal occipital-vertebral relationships.[27] The magnitude of distraction measured at the basion-dens interval in these studies is similar to the axial distraction of the occiput from the spine that we measured in our cadavers.[27-30, 32]

Conclusions

The current presentation of our data supports several previous studies in suggesting that extrication collar designs can effectively push the head away from the shoulders resulting in grossly abnormal displacements between the occiput and the spine in the presence of a dissociative injury to the HNS complex. Although these collars are applied to millions of trauma victims each year with the intent of protecting against secondary injuries in the rare case of a serious cervical spine injury, it is in these very unstable spine injuries that the collars may be doing more harm than good. While no evidence was found in the literature to substantiate that cervical collars can truly prevent abnormal motion of a severely injured spine in a trauma patient, the current cadaver study provides supportive physical evidence that well-intentioned protocols may be devastatingly harmful.

Guidelines for cervical immobilization have changed over time from recommending in-line traction to recommending in-line stabilization. We applaud this move and suggest that definitive evidence based studies be conducted to assess optimal HNS complex stabilization techniques, their development and inclusion in future trauma guideline recommendations. These observations raise the question for a need of an entirely new concept of EMS and pre-operative cervical spine and head stabilization.

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