ABSTRACT

Objective: Orotracheal intubation (OTI) is commonly used to establish a definitive airway in major trauma victims. The relative efficacy of manual inline stabilization versus cervical collar (c-collar) immobilization in protecting the injured cervical spine (c-spine) during OTI has not been evaluated. In addition, a variety of laryngoscope blades are available to facilitate cord visualization during OTI, again with uncertain effects on the injured c-spine. This experimental, randomized, crossover trial evaluated the effects of two different immobilization techniques and three different laryngoscope blades on c-spine movement during OTI in a cadaver model of c-spine injury.

Methods: A complete C5—6 transection was performed using an osteotome on 14 fresh frozen cadavers. OTI was performed in a randomized, crossover fashion using each of three laryngoscope blades the Miller straight blade, the Macintosh curved blade, and the Corzelli—London—McCoy (CLM) hinged blade. Two immobilization techniques, manual in-line stabilization and c-collar with towel rolls and tAPe, were also used in each cadaver. Intubations were recorded in real time using fluoroscopy, then transferred to video and Kodachrome still images. Outcome measures included movement across C5—6 with regard to angulation expressed in degrees of rotation, and axial distraction and anterior—posterior (A—P) subluxation with values expressed as a proportion of C5 body width. Data was analyzed using one-way ANOVA and paired t-tests.

Results: Manual in-line stabilization resulted in significantly less movement than c-collar immobilization during OTI with regards to both A-P movement and axial distraction. Use of the Miller straight blade resulted in less axial distraction than the CLM blade and less axial distraction and A-P movement than the Macintosh blade. Conclusion: Manual in-line stabilization and the Miller straight blade appeared to minimize movement during OTI in a cadaver model of c-spine injury. The clinical significance of the degree of movement observed here is unclear.

INTRODUCTION

Orotracheal intubation (OTI) has become the preferred technique for prehospital and
emergency department airway management in patients with traumatic brain injury. The incidence of coexisting cervical spine injury has been reported as high as ten percent in this population~ with. 14 percent of these possessing neurologic deficits, making cervical spine (c—spine) precautions vital in preventing new injuries or worsening existing injuries (1,2). Two techniques for maintaining c—spine precautions exist: A rigid cervical collar (c—collar), with or without towel rolls and tape, is applied in most pre— hospital systems and is often left in place during intubation; alternately, manual in—line stabilization can be used and has been advocated to be safe during OTI. The amount of c—spine movement produced during OTI with each of these techniques has not been fully elucidated.

Multiple different laryngoscope blades are available for use during OTI. The Miller straight blade and the Macintosh curved blade are the two most commonly—used blades; however., their relative safety with regard to an injured c—spine has not been defined. A new laryngoscope. blade, the Corazell—London— Mccoy (CLM) hinged blade, may decrease the amount of force required to visualize the vocal cords during OTI, ~especially in cases of difficult anatomy.~ The optimal blade in preventing c-spine movement during OTI has not been determined.

We created a cadaver model of c—spine injury to compare the relative safety of two different immobilization techniques and each of three laryngoscope blades during OTI. A randomized, crossover design was used, with outcome measures defined as axial distraction, anterior—posterior (A—P) displacement, and angular rotation.

**MATERIALS AND METHODS**

XXXXXXXXXXXXXXX authorized and approved the use of human cadavers for this study. A total of fourteen fresh—frozen cadavers were used. Cadavers were thawed for two to four hours until determined to be appropriately flexible for intubation by two senior emergency medicine residents.

A C5—6 surgical transection was created in all cadavers by a spine fellow to standardize the model of injury. An anterior approach was selected~ with a vertical incision made along the medial
aspect of the clavicular head of the sternocleidomastoid muscle. The anterior aspect of the vertebral column was entered via blunt dissection between the sternocleidomastoid and the infrahyoid muscle groups. The C5—6 interspace was located and confirmed by fluoroscopy. Surgical transection was then performed using an osteotome, with disruption of the anterior and posterior longitudinal ligaments, intervertebral disc, articular capsular ligaments, interspinous ligament, and ligamentum flavum. Complete instability of the injury was confirmed via fluoroscopy as defined by angular displacement greater than 11 degrees A-P subluxation greater than 20 percent of C5 vertebral body width during manipulation (3). This also served to eliminate the possibility of stabilization by osteophytes not visible on fluoroscopy. Overlying soft tissue was replaced and c—spines returned to a neutral position prior to beginning the trial.

Two senior emergency medicine residents then performed OTI using each of three laryngoscope blades: the Miller straight blade, the Macintosh curved blade, and the CLM hinged blade. Each of two different immobilization techniques, manual in—line stabilization and rigid c—collar with towel rolls and tape, were also used. A crossover design was employed in which all three blades and both immobilization techniques were used in random order for each cadaver.

A Polaris fluoroscope was used with direct input line to VHS video recording. The entire intubation was video taped, and real—time images were later frozen at the point of maximal C5-6 separation and transferred to Kodachrome slide film using a 35 mm camera mounted on a tripod at a fixed distance from the monitor. These still frames were then projected onto-a screen to allow measurements to be made (Figure 1). Confirmation of proper endotracheal tube positioning was confirmed on fluoroscope.

To determine the amount of motion across the unstable c—spine lesion, we defined movement in three planes as our primary outcome measures. All values represented the change from baseline prior to laryngoscopy to the point of maximal displacement. Axial distraction was calculated as the change in CS and C6 intervertebral distance. This value was calculated as an average of the change in intervertebral distance between the anterior and posterior aspects of CS and C6, with a positive value indicating axial separation. The measurement of A—P displacement was
defined as the change in horizontal distance between the anterior—inferior portion of the body of CS and the anterior—superior portion of the body of C6. The absolute value of A-P displacement was used, as inipingement into the spinal canal by either CS or C6 was felt to be significant. Angular displacement was defined as the change in the angle between the inferior surface of the CS body and the superior surface of the C6 body. A positive value implies an opening of the anterior aspect of the intervertebral space. These are represented in Figure 2. Both A—P displacement and axial distraction were expressed as a proportion of CS body width to account for xray beam diffraction and variable amounts of enlargement with projection, as well as to account for variability in vertebral body and canal sizes across the cadavers. One—way repeated measures ANOVA and paired t—testing was used for data analysis, with significance set for a p—value less than 0.05.

RESULTS

Significantly less movement was observed during OTI with the use of manual in—line stabilization than c—collar immobilization with regard to A—P displacement and axial distraction. There was no significant difference with regard to angular displacement (Figure 3). Significant differences were observed between the blades— with less movement during OTI observed with the use of the Miller straight laryngoscope blade when compared to the Macintosh blade with regard to A-P displacement and when compared to both the Macintosh and the CLM blades with regard to axial distraction. There were no significant differences between the blades with regard to angular displacement (Figure 4).

DISCUSSION

Manual in—line stabilization resulted in less c—spine movement than c— collar immobilization with both towel rolls and tape in a cadaver model of c— spine injury. This suggests that manual in—line stabilization may be safer in protecting the injured c-spine during OTI., especially with low cervical injuries. The c—collar may act as a fulcrum during laryngoscope blade
engagement or may obstruct vocal cord visualization and require the application of additional force. We also observed a slight advantage with use of the Miller straight blade as compared to the Macintosh curved blade and the CLM hinged blade.

Because of the low incidence of c-spine injuries and the difficulties in performing controlled trials, previous research has utilized retrospective reviews and used healthy volunteers to compare c—spine stabilization techniques (4—9). Although OTI appears to be safe when proper immobilization techniques are applied, neither manual in—line stabilization nor c—collar immobilization has been demonstrated to be superior. One study used a single cadaver with a c—spine injury and plain radiographs to document movement. The authors observed that a rigid c—collar resulted in more movement during OTI than no stabilization at all, but no comparison to manual in—line stabilization was made (10).

Axial traction is no longer recommended as a stabilization technique in trauma patients with suspected c—spine injury due to concerns for exacerbating a pre-existing c-spine injury ~by hyperdistraction at the fracture. site. One study documented an increased amount of axial movement during application of axial traction in patients with c—spine fractures versus those with an intact c-spine (11). In addition, new neurologic deficits and the exacerbation of pre-existing deficits have been documented with axial traction (12—15).

Little has been written about the use of manual in—line stabilization without axial traction during OTI of patients with potential c—spine injuries. Evidence does exist, however, that release of the anterior compartment of the c—collar may facilitate vocal cord visualization during OTI (16,17). These results and our findings here suggest that maintaining a patient in full c-collars with towel rolls and tape may both increase c-spine movement and hinder vocal cord visualization with OTI.

Although multiple studies have addressed the issue of blade selection for patients with potential c—spine injuries, the results have been equivocal with no blade emerging as superior. Many studies have evaluated this question indirectly, using outcome measures such as amount of
force required and visual grade achieved (18,19). In one study the Miller straight blade required 30% less head extension and force to be exerted than the Macintosh during OTI of healthy subjects (20). One study using a single cadaver with a c-spine injury observed no difference between the Miller straight blade and Macintosh curved blade with regard to c-spine movement during OTI (21). The recently introduced CLM hinged blade appears to have some advantages over the Miller straight blade and Macintosh curved blade with regard to head extension and force required (18,22). The CLM blade has not been evaluated in a c—spine injury model. Anecdotal evidence suggests that the ClAM blade may also be useful in cases of complicated anatomy and may reduce the catecholamine response to OTI, factors which we did not evaluate in our study (23,24).

The amount of movement across a c—spine injury required to exacerbate an existing c-spine injury has not been fully elucidated. Although previous studies document discrepancies ibetween the degree of c-spine injury and the incidence of neurologic damage, A—P displacement into the spinal canal appears to have a significantly worse prognosis with regard to neurologic outcome ~25— 28). One study demonstrated that athletes with abnormally narrow spinal canals have a higher incidence of neurologic dysfunction following c-spine injury (29) This led to the development of the Torge ratio, defined as the canal size divided by vertebral body width at the same cervical level. Individuals with a Torge ratio less than 0.8 (normal = 1.0) appear to be at higher risk for spinal neurapraxia after sustaining a c-spine injury. Although this cannot be extrapolated to define a safe amount of displacement into the canal during OTI of c—spine—injured patients, it provides further support for recommendations to minimize this movement whenever possible. This outcome also implies that the ratio of displacement relative to vertebral body width may have more clinical significance that the absolute amount of displacement when reporting outcome measures, leading to our use of proportions of CS body width rather than absolute values in this study. In addition, our use of proportions for both A-P displacement and for axial distraction eliminated the difficulties in standardizing units of length given-the variability in xray diffraction with fluoroscopy and subsequent video projection in obtaining measurements.

The amount of angular displacement necessary for cord damage is also unclear. Clinical standards based upon retrospective data have been developed which regard angulation exceeding 11
degrees to be unstable; however, a significant amount of individual variability exists (30). There is even less experimental evidence regarding the amount of axial distraction considered clinically significant. Much of our current practice is based on studies regarding axial traction for OTI as mentioned above. Thus, we are unable to determine the clinical significance of any of the results determined in our study and operated under the assumption that minimizing the amount of c-spine movement is important in preventing adverse neurologic outcomes in this population.

Other airway techniques may provide additional safety when managing potential c-spine injuries but were not studied here. Nasotracheal intubation may result in less c-spine movement than OTI, but it requires that the patient be conscious with spontaneous respirations and has a significant incidence of complications reported from 3 to 20 percent, including bacteremia, bleeding and local tissue damage (31,32). Furthermore, if concerns exist for a possible cribriform plate fracture, nasotracheal intubation should not be performed due to the risk of intracranial penetration, limiting its utility in trauma patients. The amount of c—spine movement during cricothyrotomy is unknown and the procedure is invasive with frequent complications, including hemorrhage, tracheal injury, and infection (33).

There are obvious limitations in applying the results of a cadaver model to human patients. No clinical outcome measures are available in non—living subjects, and tissue characteristics change significantly after death. We attempted to standardize injuries by using a single individual with experience in spinal surgery to create all transections, which were then evaluated -fluoroscopically prior to data acquisition... In the clinical setting, however, no two fractures are the same...

As discussed above, the clinical significance and generalizability of the degree of movement observed here has not been established. In addition, our model does not take into account the degree of trauma inflicted upon the cord by the fracture force. This may be more significant than any subsequent movement. Unfortunately, the ideal model to -address these issues does not exist, and controlled human trials are methodologically -difficult and ethically questionable.
Lastly, the transfer of fluoroscopic images to slide film and subsequent measurement of projected images was performed, for convenience—and may have resulted in measurement inaccuracies. We attempted to overcome this issue through the use of proportions as discussed above. Fluoroscopy appears to have some distinct advantages over x-ray evaluation of spinal movement in capturing the extremes of movement, as this is a dynamic rather than a static modality. Ultimately, digitization of fluoroscopic images with computerized calculation of measurements may be the most accurate and efficient way to acquire data.

We have demonstrated that manual in-line stabilization appears to allow less movement during OTI than c-collar immobilization in a cadaver model of spine injury. In addition, the Miller straight blade laryngoscope was also observed to minimize c-spine movement during OTI when compared with either the Macintosh curved blade or a CLM hinged blade.
REFERENCES


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Figure 1: Kodachrome images utilized in data acquisition. The injured c—spine model prior to laryngoscope blade engagement (left) and with full engagement during orotracheal intubation (right).

Figure 2: Schematic representation of C5—C6 injury and movement definitions as primary outcome measures (a = axial distraction, d = anterior—posterior displacement, and ~ = angular displacement).

Figure 3: Manual in—line stabilization versus cervical collar immobilization with towel rolls and tape with regard to movement across an injured cervical spine during orotracheal intubation.


Figure 4: Comparison between Miller straight blade, Macintosh curved blade, and Corazelli—London—McCoy hinged blade with regard to movement across an injured cervical spine during orotracheal intubation.
