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Does the novel lateral trauma position cause more motion in an unstable cervical spine injury than the logroll maneuver?

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ABSTRACT

Objective: Prehospital personnel who lack advanced airway management training must rely on basic techniques when transporting unconscious trauma patients. The supine position is associated with a loss of airway patency when compared to lateral recumbent positions. Thus, an inherent conflict exists between securing an open airway using the recovery position and maintaining spinal immobilization in the supine position. The lateral trauma position is a novel technique that aims to combine airway management with spinal precautions. The objective of this study was to compare the spinal motion allowed by the novel lateral trauma position and the well-established log-roll maneuver.
Methods: Using a full-body cadaver model with an induced globally unstable cervical spine (C5-C6) lesion, we investigated the mean range of motion (ROM) produced at the site of the injury in six dimensions by performing the two maneuvers using an electromagnetic tracking device.
Results: Compared to the log-roll maneuver, the lateral trauma position caused similar mean ROM in five of the six dimensions. Only medial/lateral linear motion was significantly greater in the lateral trauma position (1.4 mm (95% confidence interval [CI] 0.4, 2.4 mm)).
Conclusions: In this cadaver study, the novel lateral trauma position and the well-established log-roll maneuver resulted in comparable amounts of motion in an unstable cervical spine injury model. We suggest that the lateral trauma position may be considered for unconscious non-intubated trauma patients.

1. Introduction

In unconscious trauma patients, airway maintenance with concurrent cervical spine protection is a priority [1,2]. In their classic paper from 1959, Safar et al. found that in the supine position, unconsciousness was associated with upper airway obstruction [3]. Airway compromise in non-intubated patients has long been a concern [4-6]. A recent systematic review and meta-analysis revealed that airway patency in unconscious individuals was improved in the lateral versus supine position [7]. To minimize the risk of upper airway obstruction, European guidelines have, for decades, recommended the use of the recovery position [8-12]. However, since the 1960s, increased focus has been placed on the risk of secondary neurological damage to patients with spinal injuries [13,14]. Due to this concern, normative teaching systems, such as Prehospital Trauma Life Support (PHTLS) and Advanced Trauma Life Support (ATLS), place great emphasis on the spinal immobilization of patients in the supine position, even for

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unconscious trauma patients [15,16]. Thus, an inherent conflict exists between securing an open airway using a lateral position and maintaining spinal immobilization in the supine position. While prehospital personnel with advanced airway management training can secure an open airway using endotracheal intubation (ETI) combined with spinal immobilization [17], basic providers are left with few options. The conflict between the two considerations may intensify in cases of non-intubated patients who are regurgitating or vomiting or have a facial injury with ongoing upper airway hemorrhage [2,16]. Different approaches to solving this issue have been pursued. The High Arm IN Endangered Spine (HAINES) position was proposed in 1996 as a first aid measure not meant for transportation [18,19]. If a patient immobilized on a backboard vomits during transportation, the PHTLS guidelines suggest rotating the backboard to the side [16]. Neither of these suggestions seems to represent optimal solutions.

To resolve the dilemma of having to choose between these conflicting concerns, a novel maneuver, the lateral trauma position, has been developed [20,21]. The lateral trauma position aims to combine airway maintenance with spinal protection during transportation [21]. Use of the lateral trauma position has been suggested in Scandinavian prehospital airway management guidelines [20], and it has been integrated into clinical practice to some extent [21]. The maneuver was designed for a minimum two-person emergency medical services (EMS) crew (Figs. 1 and 2). In most respects, it resembles the four-person log-roll maneuver, which is considered safe, and is used on a routine basis in trauma patients [15,16].

Any movement or positioning may theoretically cause detrimental and possibly catastrophic damage to patients with an unstable cervical spine injury. A previous study [22] compared the cervical motion provoked by the lateral trauma position with the well-established recovery position [12] and two versions of the HAINES position [18]. They found that the lateral trauma position caused less motion than the recovery position [22]. However, to date, no study has investigated cervical spine motion associated with the lateral trauma position compared to the log-roll maneuver.

In this cadaver study, we aimed to examine the motion induced during lateral positioning in the log-roll maneuver and the lateral trauma position in the same standardized cervical spine injury model.

2. Methods

2.1. Study design

The study was an exploratory crossover block randomized biomechanical cadaver study. The study protocol was reviewed by the Bay Pines Veterans Administration Healthcare System Research and Development Committee (Bay Pines, FL, USA), who determined that it did not require approval because it did not involve human subject research (protocol number 2889). The Norwegian Regional Ethical Committee exempted the study from registration in Norway because all data were de-identified to all investigators (reference number 2013/919).

2.2. Study setting and population

The study was conducted in a laboratory at the Center for Advanced Medical Learning & Simulation at the University of South Florida (Tampa, FL, USA). A total of five cadavers were used in the study.

2.3. Study protocol

A certified spinal surgeon created a global cervical instability between the C5 and C6 vertebrae (C5-C6) by excising the supraspinous and interspinous ligaments, ligamentum flavum, spinal cord, facet capsules, anterior and posterior longitudinal ligaments, and intervertebral discs. The same surgeon performed all the surgical procedures to reduce the number of possible sources of variation.

The cadavers were then moved from the supine position to one of the two positions under study: the log-roll [16] and the lateral trauma position [21]. After application of a standard cervical collar (Ambu® Perfit ACE, Ambu A/S, Ballerup, Denmark), four people conducted a standard log-roll maneuver. Two people performed the lateral trauma position after application of the same standard cervical collar. One person stabilized the head and neck, while the other angled the right knee at 90 degrees with the left arm perpendicular to the body and then rolled the cadaver over in coordination with the person holding the head by gripping the right hip and shoulder. Padding was then placed under the cadaver's head to allow for neutral alignment of the spine (Figs. 1 and 2). The same people were assigned to perform the techniques to avoid inter-clinician variability. The techniques were repeated three times on each cadaver. The testing order of the techniques was randomized using an online program (https://www.randomizer.org/).

2.4. Measurements

We applied a previously developed and validated cadaver model [23-29] using an electromagnetic tracking device (Liberty, Polhemus Inc.™, Colchester, VT, USA) to measure both angular and linear motion. Voss et al. determined this method to be reliable [30]. The tracking device measures angulation and position of the sensors in an electromagnetic field, recording linear and angular motion between the two sensors applied at a rate of 240 times/seconds (240 Hz). In this study, sensors were attached to the posterior aspects of the C5 and C6 vertebrae. We placed the system's transmitter in the cadaver's chest cavity to minimize the distance to the sensors, thereby optimizing the accuracy of the measurements. According to the manufacturer, the position resolution was 0.0002 in (0.005 mm), and the orientation resolution was 0.0014 degrees over a 24-inch range [31].

Fig. 1. The Lateral trauma position during turning.

Fig. 2. The Lateral trauma position completed. Note the padding under the head.

The outcome measures of the study consisted of angular and linear motion in six dimensions: flexion/extension, axial rotation and lateral bending (degrees), and anterior-posterior motion and axial and medial/lateral linear motion (mm), all of which were measured as total range of motion (ROM; calculated as maximum minus minimum values) (Fig. 3).

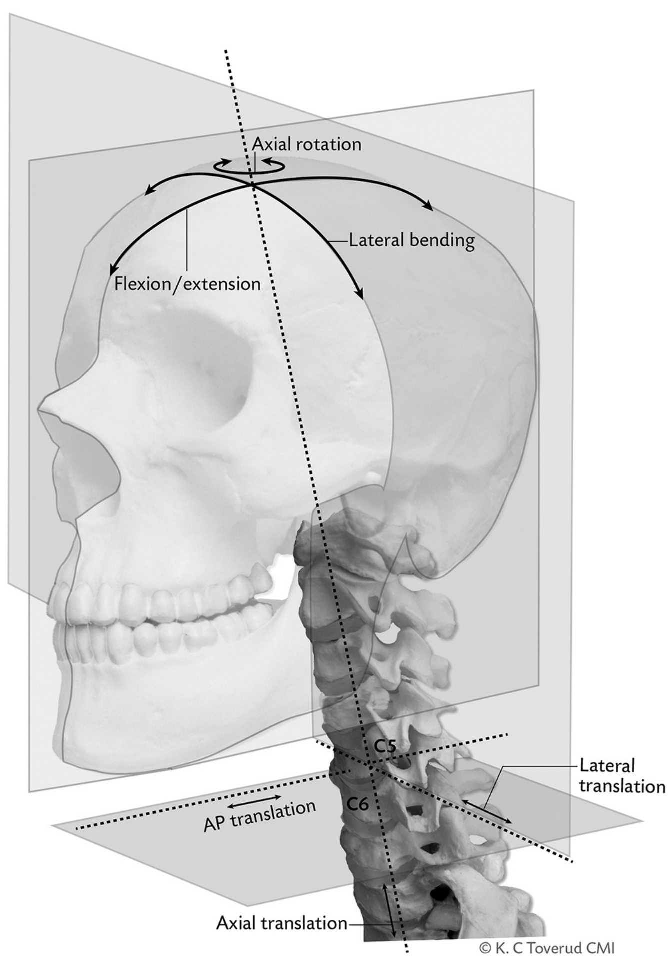

Fig. 3. Planes of angular motion and axes of linear motion (translation) recorded. Printed with permission from © Kari C. Toverud, CMI.

2.5. Data analysis

The ROMs in all six dimensions, three angular and three linear, were visualized using box plots. The six ROMs were then used as outcome variables in six regression models, using a generalized linear mixed model (GLMM). The GLMM is a generalization of standard linear regression, adjusting for the correlation introduced in the dataset that results from multiple measurements on the same test subjects. Technique (the log-roll maneuver and the lateral trauma position) was included in the six regression models as a two-level categorical explanatory variable. The log-roll maneuver is commonly applied in trauma care and was therefore used as the reference category. The results for the log-roll maneuver are thus presented as the mean effects of the method (i.e., the absolute motion when executing the log-roll), while for the lateral trauma position the results are presented relative to the reference category (i.e., as the mean estimated difference in motion compared to the log-roll maneuver). All results are presented with 95% confidence intervals (95% CIs). Approximate 95% CIs were calculated as the mean $\pm$ 1.96 $\times$ standard error of the mean (SEM).

There is a risk of establishing a clinician learning or, conversely, a fatigue effect when performing repeated measures on the same cadaver. Therefore, we also included the sequence order as a categorical covariate in all six regression models. However, the effect of repetition was not statistically significant in any of the six regression models and is thus not included in the final regression analyses reported here.

All p-values $<$0.05 were considered statistically significant. All analyses were performed with the freeware statistical software package R 3.1 [32].

3. Results

The study subjects included five human cadavers, three males and two females, aged 48 to 81 years, with body mass indexes (BMIs) ranging from 18 to 26 kg/m^2 and with no previous history of spinal injury or disease.

Both the log-roll maneuver and the lateral trauma position caused some motion in the induced globally unstable cervical spine lesions (Fig. 4). Visual inspection of the data indicated that the lateral trauma position and the log-roll maneuver generally caused comparable motion (Fig. 4).

Comparing the mean ROM for the two techniques in the six regression models, we found that the mean ROM for the lateral trauma position was not significantly different from the means of the log-roll maneuver in five of the six dimensions. Only along the medial/lateral linear axis did the lateral trauma position result in a significantly increased movement compared to the log-roll maneuver (1.4 mm more, 95% CI 0.4, 2.4 mm, $p = 0.011$) of linear motion. A similar tendency

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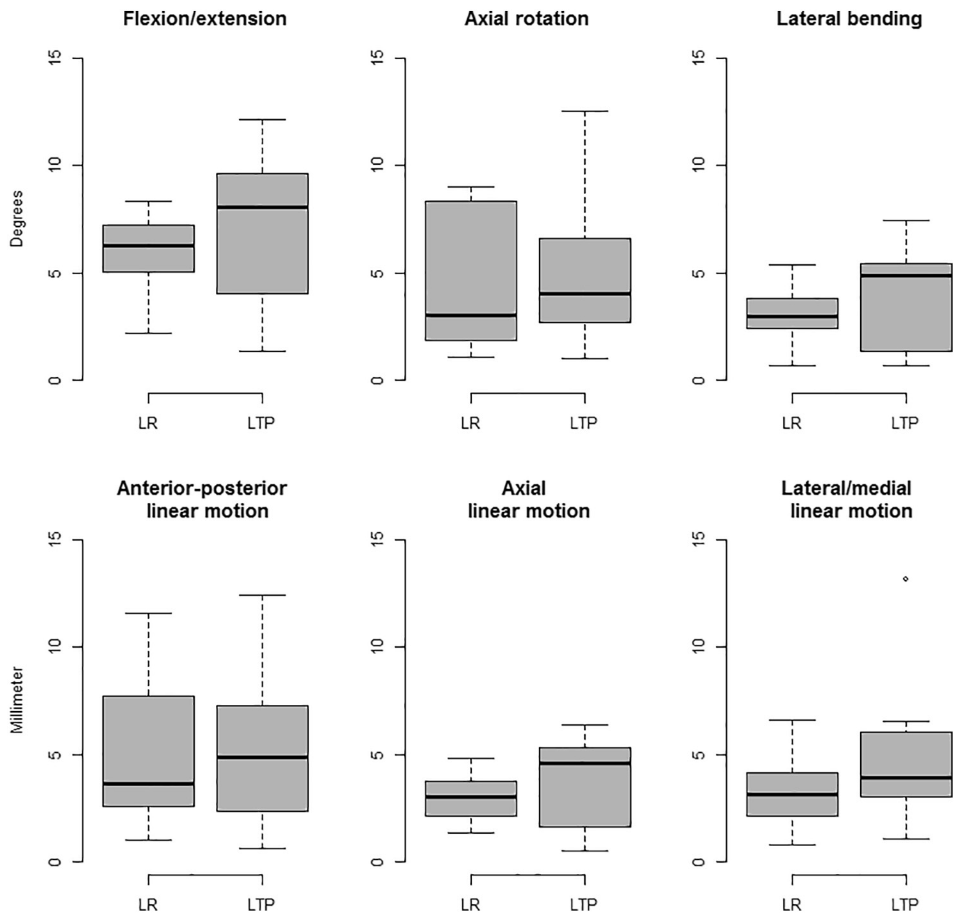

Fig. 4. Boxplot of the observed motion in all six dimensions measured logroll (LR) and the lateral trauma position (LTP).

was noted for flexion/extension, but the result was not statistically significant (1.2 degrees more, 95% CI 0.0, 2.4, $p = 0.060$) (Tables 1 and 2).

4. Discussion

In this cadaver study, we found that both the log-roll maneuver and the lateral trauma position caused motion in the unstable cervical spine lesion. However, overall, the two techniques seemed to cause comparable motion in the unstable cervical spine lesion.

Based on the findings of Conrad et al. [25], it is unsurprising that the widely used and presumably safe log-roll maneuver itself created some spinal motion. As the log-roll is extensively used throughout the world, it may be assumed that deleterious effects would have been reported over the years. A recent systematic review did not reveal any evidence of neurological harm caused by any type of lateral positioning, including the log-roll maneuver [33]. This result was confirmed by Oto et al. [34],

Table 1
Rotational motion. Results of the regression analysis using a generalized linear mixed model (GLMM). Results for the lateral trauma position are provided *relative* to the reference category (the log-roll technique).

	Flexion/extension (degrees)		Axial rotation (degrees)		Lateral bending (degrees)	
	Estimate (95% CI)	*p*-value	Estimate (95% CI)	*p*-value	Estimate (95% CI)	*p*-value
Log-roll[a]	5.9 (3.9,7.9)	0.000	4.6 (2.3, 6.9)	0.000	3.1 (1.0, 5.1)	0.005
LTP	1.2 (0.0, 2.4)	0.060	0.1 (−1.8, 2.0)	0.941	0.7 (−0.9, 2.2)	0.396

[a] Reference category/intercept.

who also concluded that "early secondary neurological deteriorations after blunt spinal trauma are exceptionally rare." Although a lack of evidence does not necessarily demonstrate the absence of harm, it seems reasonable that the motion induced by the log-roll maneuver could be used as a base for comparison for other lateral positioning techniques.

Whether the results of our cadaver study can be used to claim that the lateral trauma position is clinically safe remains unknown. In Europe, there is a long-held notion that airway patency in unconscious individuals is improved in the lateral versus the supine position, as reflected by earlier and current guidelines [8-12,20,35]. A recent systematic review and meta-analysis supports this finding [7]. Earlier North American resuscitation guidelines did not identify sufficient evidence to favor any side-lying positions [36]. The current guidelines state that "… it may be reasonable to place him or her in a lateral side-lying recovery position" [37]. However, for unconscious trauma patients, the same guidelines recommend to move a patient with a blocked airway "… only as needed to open the airway…" [37].

There may be several reasons for the earlier difference between the European and North American guidelines. The evidence may have been judged differently due to the strongly normative role of ATLS and PHTLS training in North America, which emphasizes the importance of spinal immobilization [15,16]. Furthermore, medicolegal considerations may have resulted in a stronger emphasis on the possible harm of moving a patient with a possibly unstable spinal injury. Finally, due to the absence of sufficient evidence, regional traditions and dogma may have prevailed.

Severe traumatic brain injury (STBI) is associated with high mortality and morbidity [38] and may be exacerbated by airway obstruction leading to hypoventilation and hypoxia [39-46]. To balance the risk to STBI patients, the incidence of cervical spine injury in these patients

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Table 2
Linear motion. Results of the regression analysis using a generalized linear mixed model (GLMM). Results for the lateral trauma position are provided *relative* to the reference category (the log-roll technique).

	Anterior-posterior linear motion (mm)		Axial linear motion (mm)		Medial/lateral linear motion (mm)	
	Estimate (95% CI)	*p*-value	Estimate (95% CI)	*p*-value	Estimate (95% CI)	*p*-value
Log-roll[a]	5.0 (2.7, 7.3)	0.000	2.9 (1.4, 4.4)	0.000	3.3 (1.4, 5.1)	0.001
LTP	0.1 (−1.7, 1.8)	0.916	0.7 (−0.1, 1.5)	0.102	1.4 (0.4, 2.4)	0.011

[a] Reference category/intercept.

should also be taken into consideration. Most studies conclude that the incidence of cervical spine injury in STBI patients is <10% [47-49] and that the incidence of an unstable cervical spine injury is likely much lower [47,50]. However, secondary neurological deterioration during prehospital management may have devastating consequences and obvious medicolegal implications. Furthermore, major training systems, such as the PHTLS, present a governing view on the topic by predominantly emphasizing immobilization in the supine position. However, the only study that compared this regime with a lack of prehospital immobilization did not identify any benefit of strict immobilization protocols [51]. Recent data have also indicated that the lateral position could be beneficial to spinal injury patients [52]. A method that encompasses both airway maintenance in the lateral position and cervical spine precautions could be of great benefit to this vulnerable group of patients.

The motivation behind the development of the lateral trauma position was to reduce harm caused by the loss of airway patency in the supine position while at the same time allowing for spinal precautions [21]. Based on the wide in-hospital use of the four-person log-roll maneuver for trauma patients [15], we suggest that the two-person lateral trauma position intended for use by EMS personnel constitutes an appropriate balance between the possible harm in leaving a non-intubated, unconscious patient in the supine position versus turning them to a fixed lateral position. This method is now also recommended by recent Scandinavian guidelines [35] and has received attention by North American EMS [53].

4.1. Limitations

There are several obvious limitations to our study. First, the results are limited to the biomechanical outcomes in a cadaver study; it is not possible to analyze neurological outcomes for obvious reasons. However, we are not aware of clinical data that demonstrate an association between the degree of motion and neurological outcomes, and it is unlikely that such data will be available in the near future. Second, it may be argued that the standardized global cervical instability in our model is far greater than that observed in most real-life injuries. Thus, our model may be regarded as very sensitive and a worst-case scenario. Third, we did not measure motion during transport, only during the phase of initial positioning. However, based on our clinical experience, we deemed that the motion that occurred during the initial positioning would be far greater than the motion that occurred during transport, which consequently led to the investigation of the positioning phase. Fourth, the study was performed under controlled laboratory conditions, rather than in a real-life prehospital emergency situation. Fifth, our study subjects may not be reflective of the general trauma population. Finally, the statistical power of our model is unknown. Without a known, clinically meaningful difference regarding biomechanical outcomes, a pre-study sample size calculation could not be conducted. Post hoc power calculations are generally discouraged [54,55]. Based on our previous experience from similar studies [23-29], we deemed the number of cadavers used to be sufficient to demonstrate statistically significant differences.

5. Conclusions

In this cadaver study, we found that the novel lateral trauma position and the well-established log-roll maneuver resulted in comparable amounts of motion in an unstable cervical spine injury model. Thus, we suggest that the lateral trauma position may be considered for unconscious non-intubated trauma patients.

Author contribution

PKH and ES conceived the study; PKH, MBH and BPC designed the study protocol. PKH, MBH, SA, MP and GRR conducted the trial. JR conducted the statistical analyses. PKH and ES drafted the manuscript, and all authors contributed to its revision. PKH takes responsibility for the paper as a whole.

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Prior presentation

None.

Consent

Written informed consent was obtained from the models for publication of the accompanying images.

Conflict of interest

PKH developed the concept of LTP, but has gained no economical benefit thereof, and reports no other conflict of interest, economical or other. The remaining authors report no conflict of interest, economical or other.

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