Motion in the unstable thoracolumbar spine when spine boarding a prone patient

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Introduction: Previous research has found that the log roll (LR) technique produces significant motion in the spinal column while transferring a supine patient onto a spine board. The purpose of this project was to determine whether log rolling a patient with an unstable spine from prone to supine with a pulling motion provides better thoracolumbar immobilization compared to log rolling with a push technique.

Methods: A global instability was surgically created at the L1 level in five cadavers. Two spine-boarding protocols were tested (LR Push and LR Pull). Both techniques entailed performing a 180° LR rotation of the prone patient from the ground to the supine position on the spine board. An electromagnetic tracking device registered motion between the T12 and L2 vertebral segments. Six motion parameters were tracked. Repeated-measures statistical analysis was performed to evaluate angular and translational motion.

Results: Less motion was produced during the LR Push compared to the LR Pull for all six motion parameters. The difference was statistically significant for three of the six parameters (flexion–extension, axial translation, and anterior–posterior (A–P) translation).

Conclusions: Both the LR Push and LR Pull generated significant motion in the thoracolumbar spine during the prone to supine LR. The LR Push technique produced statistically less motion than the LR Pull, and should be considered when a prone patient with a suspected thoracolumbar injury needs to be transferred to a long spine board. More research is needed to identify techniques to further reduce the motion in the unstable spine during prone to supine LR.

Keywords: Spine, Fracture, Instability, Vertebrae trauma care, Acute, Thoracolumbar injury, Transfer techniques, Log roll, Spine board

Introduction

In the case of an actual or suspected spinal injury, it is critical that the person be transported to a medical facility to receive care. Before transport, the patient must be stabilized and secured on an immobilization device, such as the long spine board, to prevent further neurological damage. Unfortunately, the act of transferring a patient onto the long spine board can create undesirable motion for an injured spine. It has been estimated that spinal injuries may be exacerbated in 3–25% of cases during the early stages of injury management.¹ To reduce these risks, medical personnel must develop transfer techniques that take into consideration the location of a suspected spinal cord injury (cervical or thoracolumbar) and

the physical position of the patient when found (supine or prone).

Previous research has attempted to link the type of spinal cord injury with its safest method of patient transfer. The lift and slide (LS) technique, rather than the log roll (LR), has been recommended for spine-boarding patients found in the supine position with a cervical instability.^{2,3} For patients with thoracolumbar injury thoracolumbar (TL) injury, the LR has been found to be inadequate.^{3,4} In a study by McGuire *et al.*,⁴ the LR produced 30° of excess angular motion in a cadaver with an L1–L2 instability. Because of this, alternatives to the LR, such as the LS and 6+ Person Lift, have been recommended to spine board a supine person with a TL injury.^{3,4}

When someone is found in the prone position, rescuers must implement the LR. It is the only technique that enables the rotation of the patient 180° before

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immobilization onto the spine board. The goal of this project was to determine which LR variation, the LR Push or the LR Pull,⁵ would result in the least spinal movement for someone with lumbar instability who is found in the prone position.

Methods

Five fresh, lightly embalmed cadavers with no previous history of lumbar spine pathology were obtained from the university Anatomical Gift Program. The identities of the cadavers were protected and the university policy for handling of donor specimens was followed strictly. A three-column global instability was created at the L1 level by performing an anterior corpectomy of L1 and surgical transection of the posterior ligamentous complex and facet capsules. This model represents a condition of lumbar spine instability sufficient to endanger the spinal cord. The instability was verified by manually positioning the specimens into a lumbar flexion pose and measuring the range of motion between T12 and L2.

An electromagnetic motion analysis device (Liberty device; Polhemus Inc., Colchester, VT, USA) was used to assess the amount of dynamic angulation and translation motion in all three anatomical planes (flexion, lateral bending, axial rotation, medial-lateral translation, anterior-posterior (A-P) translation, and axial translation) during each maneuver. The Liberty device uses electromagnetic fields to establish the three-dimensional position and orientation of its sensors. The Liberty detects angular motions with an accuracy of 0.3° within its optimal operating range of 10–70 cm (manufacturer's specifications).⁶ This technology has been used extensively in previous studies by our group and others to document motion in the spine.^{1,3,4,7–14} This system consists of one transmitter that emits an electromagnetic field and sensors with embedded

orthogonal coils that detect position and orientation. Signals from the sensors were recorded for processing at a sampling rate of 240 Hz. For the current study, sensors were fixed to the lateral bodies of T12 and L2 using custom-made fiberglass mounting brackets. The relative motion that occurred between T12 and L2 was measured as the cadavers were moved. The data were recorded directly from the Liberty device onto a laptop computer. Joint angles were calculated using previously described methods.^{7,12,15,16}

The LR Push and the LR Pull maneuvers were performed sequentially, in a random order, on each cadaver. Each maneuver was performed six times to try to ensure consistent results were observed. A repeated measures ANOVA was used to determine differences between the log-rolling techniques. An *a priori* *P* value was set at 0.05.

LR Pull

Five rescuers were required for the maneuver (Fig. 1). Rescuer 1 remained at the patient's head and provided stabilization to the cervical spine. Rescuers 2–4 were positioned along the patient's body opposite to the direction that the patient's head was facing: rescuer 2 was at the shoulders and chest, rescuer 3 at the hips, and rescuer 4 in control of the patient's legs. Rescuer 5 was in charge of the spine board. Rescuer 1 started the process by stabilizing the patient's head in a crossed hand position in which the hands were uncrossed by the end of the maneuver. On command from rescuer 1, rescuers 2–4 slowly pulled the patient toward them as rescuer 5 positioned the spine board between their arms and the patient's body. The patient was then slowly lowered onto the spine board.⁵

LR Push

The LR Push was completed with five rescuers (Fig. 2). Rescuer 1 remained at the patient's head and provided

Figure 1 Sequence of the log roll pull procedure. In frame A, the victim is prone facing left and the rescuers are positioned on the victims' right. The log roll is performed with a counter-clockwise rotation, pulling the victim toward the rescuers. In frame B, the spine board has been inserted between the rescuers and the victim at approximately a 45 degree angle. In frame C, the log roll has been completed with the victim supine on the spine board, still facing left.

Figure 2 Sequence of the log roll push procedure. In frame A, the victim is prone facing left and the rescuers are positioned on the victims' left. The log roll is performed with a counter-clockwise rotation, pushing the victim away from the rescuers. In frame B, the spine board which has been held at approximately a 45 degree angle, begins to receive the victim. In frame C, the log roll has been completed with the victim supine on the spine board, still facing left.

stabilization to the cervical spine. Rescuers 2–4 were positioned at the shoulders/chest, hips and legs on the same side that the patient's head is facing. Rescuer 5 was in charge of the spine board. Rescuer 1 directed rescuers 2–4 to carefully roll the patient away from them by pushing towards rescuer 5, who was holding the spine board at a 45° angle beneath the patient. Rescuers 2–4 slowly lowered the patient onto the spine board controlled by rescuer 5.⁵

Result

Both the LR Push and LR Pull had more than 6° of motion in all directions, but less motion was produced during the LR Push than during the LR Pull for all six motion parameters (Fig. 3). The differences were statistically significant for three of the six parameters (flexion extension, axial translation, and A–P translation).

Discussion

Patients must be immobilized onto a spine board before they can be transported from the site of injury to a medical facility. For those found in the prone position, the LR maneuver must be used. There exist two types of LR variations, the LR Push and the LR Pull. For prone patients with cervical injuries, the National Athletic Trainers' Association (NATA) recommended the LR Pull over the Push. They speculated that the physical orientation of the rescuers' arms could jeopardize their hold on the patient when sliding the spine board into place.⁵ However, this recommendation is not based on the amount of spinal motion that is generated with either LR, nor does it address the best protocol for a prone patient with a suspected TL injury. In our experience, the LR Push allowed the rescuers to be in more ergonomic positions since the most effort was required when the patient was closest to the rescuers,

Figure 3 Angulation and translation during the log roll push and log roll pull procedures. There was significantly more flexion-extension ($p = 0.021$), axial translation ($p = 0.014$) and anterior-posterior translation ($p = 0.042$) motion during the log roll pull maneuver.

opposed to the LR Pull, which required maximum force when the rescuers' arms were fully extended. We also observed that the LR Push allowed the board holder to adjust the board to 'catch' the patient during the roll.

Excess spinal motion can increase the risk of neurological damage, but for individual with an unstable spine, it is not known how much motion will lead to injury? This has not yet been determined. One answer may not apply to everyone, especially when individual variation in spinal canal size and flexibility are considered. The American Academy of Orthopedic Surgeons stated that the slightest of spinal movements (1–2 mm) after trauma may dislodge bony fragments into an unstable cervical canal.¹⁷ And in a study by Willen *et al.*,¹⁸ all patients with Denis B or D burst fractures were found to have bony fragments protruding into their spinal canals that either compressed or transected the neural tissue. During patient transfer, fragments could move, causing or aggravating damage, during patient transfer. It must be assumed that any movement within the spine after a burst fracture could generate neural tissue damage. The ultimate goal is to implement a transfer maneuver that produces no motion.

Unfortunately, no such maneuver exists at this time. Both LR variations produced some movement in a cadaver with TL instability. The Push technique generated more than 6° of spinal motion in all directions, whereas the Pull technique generated more than 10° of motion. However, when looking at the amount of spinal movement and its associated neurological risk, the LR Push generated less movement overall and must be assumed to be the less neurologically damaging of the two.

Although this study demonstrated that the LR Push generated less motion in the presence of a TL instability, if medical personnel suspect that the patient may have a cervical spine injury or they do not feel capable of holding the patient securely during the maneuver, they may wish to implement the LR Pull in conjunction with NATA's recommendation. In summary, it would seem that the LR Push is the best option for a prone patient, especially with a TL injury, but that the LR Pull may be suitable for someone with a cervical injury. More research is needed in this area.

The LR Push could be instituted in the event of an on-field athletic injury or after an accident, where the victim is found prone and spinal cord movement must be kept to a minimum. Subsequently, when a patient is brought into the Emergency Department on a spine board and must be turned for a thorough examination, the LR Push would be the best maneuver to use to return the patient to the supine position.

Limitations of this project exist. Cadavers, instead of living persons, were used as test subjects. A 'light' embalming formula, consisting of a diluted formalin and alcohol solution, was used in the cadavers to maintain soft tissue flexibility while delaying tissue decay. The resulting effect allows movement that is similar to an unconscious individual whose muscles are not able to assist in stabilization and protect the spine during transfers. Trials with cadaveric specimens may mimic patients who are unconscious and nonresponsive, which are typically found in traumatic situations. Another advantage of the cadaver model is that injuries can be surgically created for testing. Injuries could never be introduced into research subjects, nor could this type of research be conducted on a human with suspected or known spinal injury.

The cadavers were given a simulated unstable burst fracture at L1. A burst fracture involves the shattering or crushing of a vertebra whose bony fragments may be propelled into the spinal canal. Burst fractures often occur in motor vehicle accidents or after a fall from a great height. Although not the most common type of fracture observed, this injury model was chosen not because it represents the 'worst-case scenario' for a traumatic TL injury and would be the most challenging to treat. Proper pre-hospital management of an unstable burst fracture should be applicable to lesser injuries.

Conclusion

Ultimately, due to the amount of motion generated from each LR variation, neither maneuver is perfect. The LR Pull and LR Push both generated at least 6° of motion in all parameters and, if movement is synonymous with increased risk for neurological damage, neither can be considered ideal. Further research could be done using a support device and measuring the amount of motion it permits. The type of LR variation that produces the least amount of motion in a prone patient with a cervical injury is still to be determined – hard data could help direct future recommendations. Finally, the development of other transfer methods for a prone patient should be considered in the future.

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References

- 1 Podolsky S, Baraff LJ, Simon RR, Hoffman JR, Larmon B, Ablon W. Efficacy of cervical spine immobilization methods. *J Trauma*. 1983;23(6):461–5.

- 2 Del Rossi G, Heffernan TP, Horodyski M, Rehtine GR. The effectiveness of extrication collars tested during the execution of spine-board transfer techniques. *Spine J* 2004;4(6):619–23.
- 3 Del Rossi G, Horodyski M, Conrad BP, DiPaola CP, DiPaola MJ, Rehtine GR. Transferring patients with thoracolumbar spinal instability: are there alternatives to the log roll maneuver? *Spine* 2008;33(14):1611–5.
- 4 McGuire RA, Neville S, Green BA, Watts C. Spinal instability and the log-rolling maneuver. *J Trauma* 1987;27(5):525–31.
- 5 Swartz EE, Boden BP, Courson RW, Decoster LC, Horodyski M, Norkus SA, *et al.* National athletic trainers' association position statement: acute management of the cervical spine-injured athlete. *J Athl Train* 2009;44(3):306–31.
- 6 Polhemus Inc. Liberty specifications. Available at: http://polhemus.com/polhemus_editor/assets/LIBERTY.pdf.
- 7 Conrad BP, Horodyski M, Wright J, Ruetz P, Rehtine GR. Log-rolling technique producing unacceptable motion during body position changes in patients with traumatic spinal cord injury. *J Neurosurg Spine* 2007;6(6):540–3.
- 8 DiPaola CP, Conrad BP, Horodyski MB, DiPaola MJ, Sawers A, Rehtine GR. Cervical spine motion generated with manual versus Jackson table turning methods in a cadaveric C1–C2 global instability model. *Spine* 2009;34(26):2912.
- 9 DiPaola CP, DiPaola MJ, Conrad BP, Horodyski M, Del Rossi G, Sawers A, *et al.* Comparison of thoracolumbar motion produced by manual and Jackson-table-turning methods. Study of a cadaveric instability model. *J Bone Joint Surg Am* 2008;90(8):1698–704.
- 10 DiPaola CP, Sawers A, Conrad BP, Horodyski M, DiPaola MJ, Del Rossi G, *et al.* Comparing cervical spine motion with different halo devices in a cadaveric cervical instability model. *Spine* 2009;34(2):149–55.
- 11 Horodyski M, Weight M, Conrad B, Bearden B, Kimball J, Rehtine GR. Motion generated in the unstable lumbar spine during hospital bed transfers. *J Spinal Disord Tech* 2009;22(1):45–8.
- 12 Horodyski M, DiPaola CP, DiPaola MJ, Conrad BP, Del Rossi G, Rehtine GR, 2nd. Comparison of the flat torso versus the elevated torso shoulder pad removal techniques in a cadaveric cervical spine instability model. *Spine* 2009;34(7):687–91.
- 13 Bearden BG, Conrad BP, Horodyski M, Rehtine GR. Motion in the unstable cervical spine: comparison of manual turning and use of the Jackson table in prone positioning. *J Neurosurg Spine* 2007;7(2):161–4.
- 14 Rehtine GR, Conrad BP, Bearden BG, Horodyski M. Biomechanical analysis of cervical and thoracolumbar spine motion in intact and partially and completely unstable cadaver spine models with kinetic bed therapy or traditional log roll. *J Trauma* 2007;62(2):383–8; discussion 388.
- 15 Del Rossi G, Rehtine GR, Conrad BP, Horodyski MB. Are scoop stretchers suitable for use on spine-injured patients? *Am J Emerg Med* 2010;28(7):751–6.
- 16 Rehtine GR, Del Rossi G, Conrad BP, Horodyski M. Motion generated in the unstable spine during hospital bed transfers. *J Trauma* 2004;57(3):609–11; discussion 611–2.
- 17 Surgeons of the AAOS. Emergency Care And Transportation of the Sick And Injured. Jones & Bartlett Learning; 2006. Sudbury, MA, USA.
- 18 Willen JA, Gaekwad UH, Kakulas BA. Burst fractures in the thoracic and lumbar spine. A clinico-neuropathologic analysis. *Spine* 1989;14(12):1316–23.
- 19 Del Rossi G, Horodyski MH, Conrad BP, Di Paola CP, Di Paola MJ, Rehtine GR. The 6-plus-person lift transfer technique compared with other methods of spine boarding. *J Athl Train* 2008;43(1):6–13.