Spinal Immobilization Adverse Effects vs. Benefits in the Trauma Patient

Michael P. Duncan
Pacific University

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Abstract

Background

Spinal Immobilization is a standard practice of preventing further injury to trauma patients with suspected severe spinal injuries. Clinical providers employ spinal immobilization devices as soon as traumatic spinal injuries are suspected. The use of spinal immobilization devices is not benign and can cause adverse complications for the patient to include restrictive breathing, obstructed airway, pain, or even death. This review assesses the current evidence of adverse effects from spinal immobilization in trauma patients.

Methods

An exhaustive search of available literature was conducted using the MEDLINE-Ovid, Web of Science, CINAHL, and Secondary References derived from articles found in the initial searches. Keywords searched included spinal immobilization, adverse, and trauma. The articles assessed trauma patients with possible spinal trauma that incurred adverse implications. The quality of relevant articles was evaluated using the GRADE Working Group guidelines.

Results

Three studies met eligibility criteria and were included in this systematic review. The studies consisted of a retrospective study and two prospective cohort studies. One study of 329 children found a statistically significant increase in pain score, rate of admission, and rate of radiological exam. The second study of 454 trauma patients reported little to no neurological effect of spinal immobilization on patients with spinal injuries. In the third study of 10 consecutive head-injured patients 90% had a rise in ICP following the application of a rigid cervical collar. All studies had a very low to moderate quality of evidence based on GRADE guidelines.

Conclusion

The effect of spinal immobilization that is associated with adverse complications such as respiratory compromise, pain, and increased mortality remains unclear. Large prospective studies are needed to evaluate the necessity of spinal immobilization. Randomized controlled trials are required in order to establish an evidence based approach to spinal injuries in trauma patients.

Keywords

Trauma, spinal immobilization, adverse effects

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The student author attests that this work is completely his/her original authorship and that no material in this work has been plagiarized, fabricated or incorrectly attributed.
Spinal Immobilization Adverse Effects vs. Benefits in the Trauma Patient

Michael Duncan

A Clinical Graduate Project Submitted to the Faculty of the
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Clinical Graduate Project Coordinator: Annjanette Sommers, PA-C, MS
Biography

[Redacted for privacy]
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List of Abbreviations

ACS  
CI  
CT  
ED  
EMS  
GCS  
ICD-9  
ICP  
MRI  
OR  
PTTs

American College of Surgeons  
Computed Tomography  
Confidence Interval  
Emergency Department  
Emergency Medical Services  
Glasgow Coma Scale  
International Classification of Disease Version 9  
Intracranial Pressure  
Magnetic Resonance Imaging  
Odds Ratio  
Pediatric Trauma Scores
Spinal Immobilization Adverse Effects vs. Benefits in the Trauma Patient

BACKGROUND

The origin of spinal immobilization for severe spinal trauma is unclear, but the first patent for such a device was shortly after the Vietnam war by inventor Glen Hare, the founder of Dyna-Med in 1974. The initial use of spinal immobilization devices was based off of anecdotal evidence that their use reduced the likeliness of further neurological injury post trauma. Since then, the use of spinal immobilization devices has become a standard practice in the Western world, and is one of the most performed interventions to trauma patients in the pre-hospital environment. This practice continues even though the actual incidence of spinal neurological trauma is rare in trauma patients, as low as 0.7%. The practice is not benign as it has an economic impact and can have adverse physiological effects on patients. The wide range of negative physical complications include increased ICP, restricted ventilations, airway obstruction, augment the risk of aspiration associated with pulmonary restriction, pressure ulcers, abnormal separations between vertebrae, and delay transport time from scene to the hospital.

Largely the economic impact is dismissed and considered benign. The cost of a cervical collar can vary from $6.00 to more than a $100.00 per unit which could be easily dismissed, but collectively when used as a disposable device the estimated cost to health care systems is substantial. Spinal immobilization in the U.S. generally includes the use of the long spine board which is most often in excess of $100.00 and the strapping systems which attach to them must be frequently replaced at a cost which may be in excess of the reusable spine board. The economic impact increases yet again if the price of training pre-hospital providers is
factored into the overall cost. Besides the most important factor of adverse affects on the patient, economic pressures in the U.S. to reduce fraud, waste, and abuse within the health care system should substantiate a further evaluation of the spinal immobilization practice.

When considering the cost and the previous studies\textsuperscript{5-10} that demonstrated possible harm of spinal immobilization, it calls into question whether there is true benefit from the practice. Therefore, the use of spinal immobilization must be called into question. Evidence based evaluations continually demonstrate that treatments do not always have the assumed desired affect, and the question must be addressed: Do the potential adverse effects outweigh the benefits of spinal immobilization in the trauma patient?

**METHODS**

An exhaustive search of available literature was conducted in November 2015 using the MEDLINE-Ovid, Web of Science, CINAHL, and Google Scholar. Keywords searched included spinal immobilization, adverse, and trauma. The search results were narrowed to include only English-language articles and human studies. References cited in the included articles were examined for additional relevant sources. Articles that assessed the effects of spinal immobilization on trauma patients were included. The quality of relevant articles was evaluated using Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group guidelines.\textsuperscript{11}

**RESULTS**

The initial literature search yielded 57 articles for review. After screening abstracts and titles for eligibility, three articles were selected that met inclusion criteria. The studies consisted of a retrospective study\textsuperscript{12} and two prospective cohort studies.\textsuperscript{13,14} One study\textsuperscript{13} examined spinal
immobilization effects in the pediatric population. The second study\textsuperscript{12} compared the effects and neurological outcomes of spinal immobilization on acute trauma patients with spinal injuries in the U.S. to similar patients in Malaysia who did not receive spinal immobilization. The third article\textsuperscript{14} focused on the acute effect of increasing ICP in 10 consecutive trauma patients with a GCS of nine or less after the application of a cervical collar. See Table I.

**Leonard et al**

This prospective cohort study\textsuperscript{13} evaluated the correlation between the use of spinal immobilization devices in the pediatric population with trauma injuries and the potential adverse effects to include increased pain, higher likeliness to undergo cervical radiography, and higher likeliness to be admitted to the hospital. The population was a convenience sample that presented to the St. Louis Children’s Hospital for evaluation of possible trauma-related injuries. The study’s population included 285 patients all under the age of 18. The inclusion criteria were met after the patients were screened at the bedside and met ACS criteria for spinal immobilization but were not immobilized, or if patients presented to the ED via EMS already with spinal immobilization applied for care of a possible traumatic injury. Additionally, the child’s guardian had to consent for patient enrollment into the study. Of the final 285 that met all inclusion criteria, 173 presented with spinal immobilization prior to evaluation by a physician and the additional 112 patients met ACS guidelines for immobilization but were not immobilized\textsuperscript{13}.

Modifications to the cohort were conducted using markers of age, mechanism of injury, Glasgow coma scale (GCS), and Pediatric Trauma Score (PTS). Sample size per group was set at 100 in order to be 90% greater than an alpha of 0.5\textsuperscript{13}. Finally the data was evaluated by a two sided t-test and chi-square analysis. This was done in order to compensate for the higher likeliness that patients who were already immobilized most likely were older or injured in a
motor vehicle crash. Pain was assessed upon arrival to the ED by using a five-point scale of hand drawn faces ranging from 0 (smiling) to 4 (crying) which represented worst pain. The rate of cervical spine imaging was identified by query of the radiology database at a later time. This made the decision making solely up to the physicians caring for the patient upon arrival. Lastly, the evaluation of likeliness of admission was gathered via chart review.\textsuperscript{13}

It was determined that pain was increased on average at one-point higher on patients that were immobilized. Children who were immobilized, were more likely to receive radiographic screening at 56.6% as compared to 13.4% likeliness of those who were not immobilized. The immobilized children as well were more likely to be admitted at a ratio of 85.7% versus 58.4%. Overall, patients treated with spinal immobilization were correlated with an increased likeliness of increased pain, radiographic screening, and admission.\textsuperscript{13} See Table II.

\textbf{Hauswald et al}

This is a 5-year retrospective cohort study\textsuperscript{12} that examined the overall effect of spinal immobilization in relation to neurological outcome in patients who sustained blunt traumatic injuries. Patients that were admitted to either the inpatient service or ED were included from January 1988 to January 1993 at The University Hospital, University of Malaya in Kuala Lumpur Malaysia and The University of New Mexico Hospital in Albuquerque, New Mexico. 454 cases were found by searching ICD-9 codes in a chart review. In the 334 U.S. cases exclusion criteria included patients with burns, victims of drowning, and isolated injures not admitted to the trauma service. The 120 Malaysia cases found did not exclude these criteria. Although, cases with compression fractures related to osteopenia were excluded in both populations. None of the patients treated in Malaysia received spinal immobilization, because
University of Malaya does not have emergency medical services. Still both hospitals had similar radiographic, resuscitative, and surgical abilities.¹²

The study also gathered data regarding the patients age, gender, level of deficit, mechanism of injury, and neurological injury type. Age was used to stratify the data by decade. The injuries were then classified by which segment of the vertebrae injured at the highest point. The mechanism of action was separated into four categories: falls, motor vehicle crash, impacts with blunt objects, and patients struck by falling objects. Neurological injury was determined by the last hospital note. The charts were reviewed by two physicians separately and blinded to the hospital of origin. Evaluation of the note determined if a patient had sustained an injury that was considered to interfere with normal functioning as compared to a patient who no longer had any neurological injury. Two tailed tests and an alpha of 0.05 was used when evaluating the data.¹²

There were 70 of the 334 U.S. patients that sustained a long term neurological injury as compared to 13 of the 120 Malaysian patients. The OR for a suspected disability was 2.03 CI (1.03-3.99) for all patients included in the study. This higher level of disability is consistent with a 2% probability that spinal immobilization has any beneficial effect. The analysis was repeated with patients that had only received cervical injuries and the OR was still 1.52 (0.64-3.64) which is consistent with a limited beneficial effect from spinal immobilization.¹² See Table II.

**Mobbs et al**

This prospective cohort study¹⁴ was conducted on 10 continuous unconscious patients with head trauma that had a GCS of nine or less. The patients presented as a convenience sample to the three medical centers in Sydney and Canberra, Australia. All patients presented to the hospital with a rigid cervical collar in place. ICP recordings were performed during initial 24-48 hours after presentation. Patients were then transferred to the ICU were the cervical collar
placement was marked. The collar was removed and the head stabilized with sandbags. The patient was subjected to a 30-minute period of minimal stimulation were no medical intervention was performed. The collar was then reapplied with minimal handling and mean ICP measurements were recorded after 3-5 minutes. The collar was immediately removed after the reading and was analyzed with the t-test.\textsuperscript{14}

Post application ICP was significantly higher than ICP recorded prior to application in all patients. The patients were separated into three observatory groups based off their baseline ICP. Patients in the first group died related to cerebral trauma. The second group had a poor outcome, and the third group had a favorable outcome. ICP increases ranged from -3 to +12 mmHg with a mean increase of 4.4 mmHg. There was no demonstration of relationship between ICP and long term negative outcomes. Although it did show evidence there may be a benefit of early removal of cervical collars on ICP in a patient with head trauma.\textsuperscript{14} See Table II.

**DISCUSSION**

The results of these reviewed studies are not revolutionary, rather there has been a multitude of cohorts since the early 1990s that have come to a similar conclusion. Despite the mounting level of evidence there has been no randomized controlled trials to substantiate this continuing practice of spinal immobilization in out-of-hospital trauma victims.\textsuperscript{9} As this practice continues unabated there remains a potential risk of injuring or even fatally endangering patients.

The focus of this systematic review, as others before it, is to prod medical providers and medical associations to reevaluate their emergency protocols for the safety of their patients. There needs to be a thorough randomized control trial in order to determine the safety of this so called benign practice. At the very least, it is essential that there is a reinvigoration of this discussion.
Discontinuing this practice may have a large positive effect on patient care. The overall reduction in cost would be extensive. Conscious to semi-conscious patients that have emesis will be able to protect their own airway because they are no longer restrained. In pre-hospital situations, medical technicians may not always be able to adequately suction a patient that is aspirating. The decrease in patient packaging and transport time to the hospital will be significantly reduced, and reduction in pre-hospital transport times improve patient outcomes.\textsuperscript{15,16} Upon arrival at the ED or Trauma Center a patient can be more easily and thoroughly evaluated by the trauma team if not initially confined by spinal immobilization. This will reduce the likelihood that a hidden injury on the patient’s ventral aspect is more readily addressed if not found initially on scene by EMS personnel.

The results of the studies reviewed\textsuperscript{12-14} were consistent across different populations and different regions of the world. Direct comparisons of each of the studies are difficult because they are evaluating different populations and are measuring different adverse effects. Across the three particular studies evaluated the OR’s were statistically significant. Cumulatively these studies build a case that adverse effects are likely and that there may be little to no benefit from spinal immobilization (see Table II).

The Leonard et al study\textsuperscript{13} was a thorough prospective study with no direct evidence of bias. The three factors assessed in the initial study included pain, the likelihood in radiographic imaging, and likelihood for admission. Pain was more likely to be elevated in the immobilized group, especially in patients that were admitted to the hospital with an OR greater than two. The pediatric patients that were immobilized had almost an eight-fold increase in likeliness to receive radiographic imaging. Lastly, at a high economic cost patients had at least four times more likeliness to be admitted as compared to the patients that met ACS guidelines for spinal
immobilization but were not immobilized. The results are of a large magnitude and demonstrate a relationship that should not be dismissed.\textsuperscript{13}

There are many limits to this study that include the study’s sample, limited blinding, and the severity of injuries in the sample. It is possible that the convenience sample used could add an unknown bias either because of location or time it presented. Eligibility for patients that presented to the physician without already being immobilized had to be screened directly. This screening can enter an element of bias into the study. The 173 patients that arrived to the hospital that were already immobilized did add an element of blinding, but because it was not directly addressed in the study the effect is unknown. Lastly since only one patient in the sample had a confirmed spinal injury it could skew the results. With the limits, the study was still appraised to a moderate level of quality because of the magnitude of correlation that was demonstrated.\textsuperscript{13}

The Hauswald et al study\textsuperscript{12} was a retrospective cohort that demonstrated less neurological disability in immobilized Malaysian patients as compared to immobilized American patients that was statistically significant to correspond to a less than 2\% chance that spinal immobilization has any beneficial effect. The study was performed in the most direct comparison possible without a randomized control trial. The standard of care in the U.S. includes the use of spinal immobilization and limits the ability of researchers to assess the effects of spinal immobilization because of legal liability. There was no direct evidence of bias, but the author had conducted other studies on the subject with similar findings which could have entered an element of bias.\textsuperscript{12}

The study’s limitations included geographic and genetic differences in the population, differences in the level of care when comparing Malaysia with the United States, severity scores were not assessed in the Malaysia cohort, and only patients that had a confirmed spinal injury
were entered into the study. The geographic and genetic differences were present, but should have limited overall effect on the sample. The level of care although different from the United States could impact the outcome, but more likely it should increase the probability of long term neurological disability in Malaysia, and the opposite was true. Lastly, the majority of trauma patients in the U.S do not even have confirmed spinal injuries and were not included in the study, which would further skew the null effect of spinal immobilization on the cohort. The study was assessed at a very low quality of evidence based on these limitations as noted in the GRADE guidelines (Table I).^{12}

Due to the very low quality of evidence in Mobbs et al study^{14} it is difficult to make clear conclusions on the increase of ICP on the trauma patient after the application of a cervical collar. There was no clearly defined bias, but the study had many limitations. The study was still included because the magnitude of effect was apparent on the study’s sample. The limitations included a convenience sample that was limited in size to only 10 patients and only one type of rigid collar was applied, and the level of the subjects ICP at baseline was already effected by underlying severity of their traumatic brain injury. Regardless of the limitations this study’s magnitude of effect demonstrates a necessary need to further evaluate the impact of spinal immobilization on trauma patients with traumatic brain injuries.^{14}

The variability across the studies^{12-14} does not provide adequate evidence to change practice but the studies themselves do provide evidence that the practice of spinal immobilization requires further investigation. The average low level quality of evidence is only low because no thorough studies have been performed. The continual result that spinal immobilization most likely has no benefit, and may possibly incur adverse side effects to the patient is alarming. Randomized clinical trials and/ or large observational studies are necessary in order to
effectively demonstrate the effect of spinal immobilization. This level of evidence should substantiate the temporary change in the standard of care in order to conduct a more thorough study under the observation and control of an institution review board.

CONCLUSION

The association between the use of spinal immobilization and adverse complications is clearly demonstrated in the three studies included in this review. A statically significant correlation between spinal immobilization was observed in two of the three studies\textsuperscript{12,13} examined. However, the limitations of these studies restrict the strength of their evidence. The limits of Mobbs et al\textsuperscript{14} only provide slight evidence of a correlation, although other systematic reviews in the past provide similar evidence that the net effect of spinal immobilization is null to adverse.\textsuperscript{7,9}

The studies and prior data do clearly illustrate the increased risk of adverse effects when utilizing spinal immobilization with trauma patients. Spinal immobilization is broadly used on a majority of trauma patients that do not have a spinal injury. It is a fact that the use of spinal immobilization does not benefit patients without a spinal injury. Providers and protocol developers need to assess the legitimacy of this practice with the potential adverse side effects demonstrated in these studies. Further research that includes randomized controlled trials must be performed to ensure the safety of patients.
References


**Table I. GRADE Evidence Profile**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Design</th>
<th>Limitations</th>
<th>Indirectness</th>
<th>Inconsistency</th>
<th>Imprecision</th>
<th>Publication bias</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leonard et al13</td>
<td>Prospective Cohort study</td>
<td>Not Serious</td>
<td>Not Serious</td>
<td>Not Serious</td>
<td>Not Serious</td>
<td>Unlikely</td>
<td>Moderate⁷</td>
</tr>
<tr>
<td>Hauswald et al12</td>
<td>Retrospective Cohort study</td>
<td>Not Serious</td>
<td>Not Serious</td>
<td>Serious⁶</td>
<td>Not Serious</td>
<td>Unlikely</td>
<td>Very Low</td>
</tr>
<tr>
<td>Mobbs et al14</td>
<td>Prospective Cohort study</td>
<td>Serious²</td>
<td>Serious⁷</td>
<td>Not Serious</td>
<td>Serious⁸</td>
<td>Unlikely</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

⁷ Upgraded due to a large treatment effect
⁶ Large uncontrollable differences in sample populations (Malaysian vs. U.S.)
⁵ Lacked a control group
⁷ Single person for application and data collection
⁸ Limited sample n=10
Table II. Summary of Findings

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
<th>Effects of spinal immobilization on Children</th>
<th>Spine-Immobilized Prior to Evaluation (n = 173)</th>
<th>Not Spine-Immobilized but Met ACS Guidelines for Spinal Immobilization (n = 112)</th>
<th>Odds Ratio/ Hazard Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leonard et al</td>
<td>Prospective cohort study</td>
<td>Pain score—median (range) 3 (0–4) 2 (0–4)</td>
<td>2.2(1.4–3.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hauswald et al</td>
<td>Retrospective Cohort study</td>
<td>Cervical spine imaging, % (95% CI) 56.6(49.0–64.2) 13.4(7.6–21.1)</td>
<td>8.2(4.5–15.4)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>ED disposition, % (95% CI) Home 58.4(50.7–65.8) 85.7(77.8–91.6) Reference</td>
<td>4.0(2.1–7.8)</td>
<td></td>
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<td></td>
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<td>Floor or transfer 31.8(24.9–39.3) 11.6(6.3–19.0)</td>
<td>5.3(1.5–19.0)</td>
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<td></td>
<td>ICU or OR 9.8(5.8–15.3) 2.7(0.6–7.6)</td>
<td>5.3(1.5–19.0)</td>
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</table>

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study design</th>
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<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
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<tr>
<td>Mobbs et al</td>
<td>Prospective Cohort Study</td>
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<td>1.03-3.99</td>
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<td></td>
<td></td>
<td>Age (by decade) 0.96</td>
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<td></td>
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<td>Level of Injury</td>
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<td>Cervical 3.82</td>
<td>1.98-7.37</td>
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<td>Thoracic 1.99</td>
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<td>Lumbrosacral 0.34</td>
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<td>Mechanism of Injury</td>
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<td></td>
<td></td>
<td>Fall 0.60</td>
<td>0.14-2.54</td>
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<td>Motor Vehicle Crash 0.91</td>
<td>0.23-3.56</td>
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<td>Low mass impact 0.38</td>
<td>0.03-4.77</td>
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<tr>
<td></td>
<td></td>
<td>Other 1.32</td>
<td>0.34-5.08</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Design</th>
<th>Number of Patients</th>
<th>Mean ICP increase</th>
<th>Range</th>
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<tbody>
<tr>
<td>Mobbs et al</td>
<td>Prospective Cohort Study</td>
<td>10</td>
<td>4.4 mmHg</td>
<td>-3 - +12 mmHg</td>
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