Comparison of a Vacuum Splint Device to a Rigid Backboard for Spinal Immobilization

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In this study, comparison of a vacuum splint device to a rigid backboard was made with respect to comfort, speed of application, and degree of immobilization. The study was a prospective, nonblinded comparative study conducted at a statewide emergency medical services (EMS) training facility and included a convenience sample of emergency medical technicians (EMT) and paramedic students. The vacuum splint was judged to be significantly more comfortable on a 10-point scale than the rigid backboard after subjects had been lying on each device for 30 minutes ($P < .001$). It was also faster to apply: 131.6 ± 24.3 seconds versus 154.6 ± 22.2 seconds ($P < .001$). Various measures of immobilization were similar for the two devices. The vacuum splint provided better immobilization of the torso and less slippage on a gradual lateral tilt. The rigid backboard with head blocks was slightly better at immobilizing the head. Vacuum splints offer a significant improvement in comfort over a traditional backboard for the patient with possible spinal injury. They can be applied in reasonable time frames and provide a similar degree of immobilization when compared to a standard rigid backboard. (Am J Emerg Med 1996;14:369-372. Copyright © 1996 by W.B. Saunders Company)

Prehospital spinal immobilization has become the standard of care for transporting patients who may have cervical spine injuries.12 The usual procedure is to strap the patient onto a wooden backboard, securing the head with tape in combination with blanket rolls, sandbags, or a variety of commercial devices.13 A rigid cervical collar is often used and the torso is secured with straps. Although some refinements to this system have been made, the practice of using a flat, rigid surface as a splint for the spine has changed very little since the 1960s.4

Rigid backboards can cause significant head, neck, and back pain in normal volunteers.5 If similar pain develops in trauma patients, it may be difficult to differentiate pain as a result of trauma from that caused by a cervical collar or the backboard. Because emergency physicians base the decision to obtain cervical spine radiographs, in part, on the presence of neck pain, many patients may be getting unnecessary radiological procedures.67

Vacuum splints contain numerous polystyrene heads encased in a flexible outer shell. They are initially soft and malleable, but when air is removed they become rigid. Since these devices conform to the shape of the patient, they seem likely that they would be more comfortable than other splinting devices.

We compared a vacuum splint mattress to a standard, wooden backboard with respect to patient comfort. We also compared the two devices with regard to the adequacy of immobilization and speed of application using human volunteers.

METHODS

Two methods of spinal immobilization were compared with respect to comfort, speed of application, and degree of immobilization. A vacuum splint device (Evac-U-Splint, Harwell Medical, Carlsbad, CA) was compared to a traditional wooden backboard. The first phase of the study evaluated the comfort and speed of application of each device. A convenience sample of 30 students was recruited from four emergency medical technician (EMT)-Basic classes. None of the students had any prior emergency medical services (EMS) field experience or knowledge of spinal immobilization techniques. All students were given training in the use of each device and allowed approximately 4 to 6 hours of practice to master each of the techniques in a practical lab setting. The students worked in groups of four, with one student selected to act as the “patient.”

The vacuum splint was applied according to the manufacturer’s recommendations except that 2-inch tape was used to secure the head rather than the velcro straps provided by the manufacturer. Previous experience with these straps indicated that they were cumbersome and did not adequately secure the head. After the splint had been flattened and smoothed out, air was removed to make it rigid in order to allow the subject to be logrolled onto the device. The air intake valve was then opened to allow air back into the system to soften it. The torso was secured using the supplied straps. Air was then removed from the vacuum splint by one student using a foot pump supplied by the manufacturer. As air was evacuated, a second student molded the splint to the head and neck as the third maintained manual stabilization of the head. The head was then secured with tape.

The wooden backboard was applied in a similar fashion with 3 students logrolling the subject onto the board. The torso was secured using 2-inch nylon straps applied in a cross-the-heart fashion and in a parallel technique over the legs. This strapping technique was the most consistently taught method in local EMT courses and was therefore used in the study. The head was secured with a headblock (Headlugger, Ferno-Washington, Inc., Wilmington, OH) and 2-inch tape. Rigid cervical collars were not used with either device during this portion of the study to eliminate discomfort caused by the collar itself.

An instructor timed each procedure and students were randomly assigned for placement on the vacuum splint or the wooden backboard first. After lying on each device for 30 minutes the students rated comfort on a 10-point scale. A score of 1 represented the comfort of a concrete slab and 10 was equivalent to their bed at...
home. Each participant had the opportunity to evaluate both devices.

The second phase of the study compared immobilization of subjects while in each of the devices. Thirty additional students were recruited from two EMT-Basic classes and one paramedic class. Students from the paramedic class had had previous experience with the rigid backboard technique but not with the vacuum splint. Individuals were immobilized in the same manner described above for the timed trials. When immobilization was measured, however, each device was evaluated both with and without the application of a rigid cervical collar (Stifneck, Laerdal, Long Beach, CA).

Immobilization was measured by placing each individual and the test device on a platform which could be tilted in a lateral direction up to a maximum of 90 degrees from the floor (horizontal tilt). The angle of tilt could be measured using a large protractor at the base of the device (Figure 1). Students were instructed to verbally indicate the point at which they first noted slippage of any part of their body during a gradual lateral tilt. This angle was then recorded. The platform was then tilted to a full 90 degrees to measure lateral movement of the head, shoulders, and hips. This procedure was chosen to simulate a maneuver commonly used by EMTs when a patient suddenly begins to vomit and is at risk for aspiration. To make these measurements, flexible metal arms were attached to the tilt platform using magnets (Figure 2). The metal arms were initially placed in contact with the nose, right shoulder, and right hip. Movement away from each flexible arm was measured in centimeters after the subject was fully tilted to 90 degrees.

Except where otherwise indicated, results are presented as mean ± SD. The Watson-Williams test was used to analyze differences between angles.8 All other data were analyzed using StatGraphics Plus version 6.0 statistical software (Manugistics, Inc., Rockville, MD). The Mann-Whitney rank sum test was used to analyze the ordinal scale comfort data, and the t test was used for speed of application. Immobilization was analyzed with analysis of variance (ANOVA) using the Tukey test for multiple comparisons. A critical value of P < .05 was considered significant.

This study was approved by the Human Research and Review Committee of the University of New Mexico. Informed consent was obtained from each study participant.

![FIGURE 1](image1.png)

**FIGURE 1.** Measurement of the angle of tilt after slippage is initially noted by the subject.

![FIGURE 2](image2.png)

**FIGURE 2.** Flexible metal arms used to measure movement of the head, shoulders, and hips after a 90-degree tilt.

### RESULTS

The vacuum splint device was found to be significantly more comfortable (Figure 3). It was also faster to apply: 131.6 ± 24.3 seconds versus 154.6 ± 22.2 seconds (P < .001).

The angle of initial slippage on gradual lateral tilt is shown in Table 1. Subjects in the vacuum splint could be tilted significantly more than those on the wooden backboard before movement was noted. Application of a rigid cervical collar did not significantly change these results.

<table>
<thead>
<tr>
<th>Device</th>
<th>Movement of Head</th>
<th>Movement of Shoulders</th>
<th>Movement of Hips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum Splint</td>
<td>71.5 cm</td>
<td>1.7 cm</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Wooden Backboard</td>
<td>61.5 cm</td>
<td>1.0 cm</td>
<td>1.0 cm</td>
</tr>
</tbody>
</table>

Tables 2 and 3 compare each of the devices with and without a cervical collar with respect to movement of each part of the body after a full 90-degree tilt. Although there was more movement of the head while in the vacuum splint, more movement of the shoulders and hips was noted with the backboard. The difference between movement at the head and movement of the shoulders was less for the vacuum splint than for the backboard (without collar: 0.8 ± 1.4 cm < 1.5 ± 1.7 cm, P < .001). Addition of a rigid cervical collar did not significantly change this relationship (0.6 ± 1.5 cm < 1.8 ± 1.5 cm, P < .001).

### DISCUSSION

Immobilization of patients with suspected spine injuries is a procedure commonly performed by EMTs in the prehospital setting. Procedures for accomplishing spinal immobilization are well described in prehospital care texts, but have changed very little since described by Farrington in 1968.1,2 Subsequent work has determined that immobilization is best accomplished by placing the patient on a rigid surface and securing the patient's head with tape along with sandbags or similar devices.3 Rigid cervical collars alone do not significantly restrict movement of the head.3,9

Recently, Chan et al5 have shown that immobilization on a rigid backboard for just 30 minutes can result in significant discomfort to the patient. Neck or back pain perceived by the patient may prompt the emergency physician to order a radiographic examination of the spine.6 Therefore it is possible that pain caused by a rigid backboard may result in unnecessary radiographs of the spine in trauma patients.

Rigid backboards have also been associated with the
development of pressure sores in spinal cord–injured patients.\textsuperscript{11,12} Such patients are unable to take pressure off bony prominences on their own. It is possible that a device that is either padded or conforms to the shape of the patient may reduce these potentially devastating complications.

Vacuum splint devices have been available for several years and offer the possibility of improved comfort because they conform to the shape of the patient. Before these devices can be recommended for general use, they should be shown to immobilize at least as well as a traditional rigid backboard. In addition, they should be easy to use and must be applied in reasonable time frames so that prompt patient transport is not delayed.

Our study showed that a vacuum splint device is significantly more comfortable than a rigid, wooden backboard. In addition, this device can be applied faster than a backboard using accepted strapping techniques. The differences noted in speed of application were not, however, clinically significant. Although other techniques for strapping the patient to a rigid backboard may have resulted in faster times, it seems fair to conclude that application of the vacuum splint does not take significantly longer. Because of design differences in the two devices, it was not possible to control for strapping technique. We therefore chose a technique for strapping a patient to the rigid backboard which was commonly taught in local EMT courses.

We measured several parameters of immobilization for both devices. When subjected to a gradual lateral tilt, slippage of the subject was noted at a much smaller angle on the rigid backboard than on the vacuum splint. When the two devices were compared using a full 90-degree tilt, small differences in immobilization were noted. Specifically, the vacuum splint was superior at immobilization of the torso, whereas the backboard provided better immobilization of the head. It was interesting to note that the difference in movement between the head and shoulders was smaller with the vacuum splint than with the rigid backboard. This suggests that there might be smaller shear forces exerted on the neck when a subject on the vacuum splint is subjected to an extreme lateral tilt.

The larger degree of movement of the head while immobilized in the vacuum splint was believed by some of the study participants to be attributable to the design of the device. There did not seem to be enough padding around the head and neck to allow tight molding in these areas. It may be useful to alter the design of the vacuum splint so that it is partially segmented to allow separate molding around the head and torso. Some of the larger subjects believed that the device needed to be wider to accommodate them.

Previous investigators have studied various immobilization devices by taking goniometric or radiographic measure-

\begin{table}
\centering
\caption{Angle of Initial Slippage With a Gradual Lateral Tilt}
\begin{tabular}{|c|c|c|}
\hline
 & Angle (degrees ± SD) & P \\
\hline
Vacuum splint without collar & 30 & 29.2 ± 7.0 & <.001 \\
Backboard without collar & 30 & 19.8 ± 4.3 & <.001 \\
Vacuum splint with collar & 30 & 30.2 ± 8.5 & <.001 \\
Backboard with collar & 30 & 20.2 ± 7.8 & <.001 \\
\hline
\end{tabular}
\end{table}

\begin{table}
\centering
\caption{Comparison of Lateral Movement at Nose, Shoulders, and Hips in Each Device When Used Without a Rigid Cervical Collar}
\begin{tabular}{|c|c|c|c|}
\hline
 & Head & Shoulders & Hips \\
\hline
Vacuum splint & 4.3 ± 1.6 & 3.5 ± 1.6 & 1.3 ± 0.9 & \\
 & <.001 & NS & <.001 \\
Backboard & 2.6 ± 1.1 & 4.1 ± 1.7 & 3.4 ± 1.5 & \\
\hline
\end{tabular}
\end{table}

\begin{table}
\centering
\caption{Comparison of Lateral Movement at Nose, Shoulders, and Hips in Each Device When Used With a Rigid Cervical Collar}
\begin{tabular}{|c|c|c|c|}
\hline
 & Head & Shoulders & Hips \\
\hline
Vacuum splint & 7.0 ± 1.4 & 4.3 ± 1.7 & 1.4 ± 1.0 & \\
 & <.001 & <.003 & <.001 \\
Backboard & 2.8 ± 1.1 & 4.6 ± 1.6 & 3.4 ± 1.6 & \\
\hline
\end{tabular}
\end{table}
ments while the subject is actively exerting pressure against the study device in various planes. Interpretation of these studies is difficult because the amount of pressure exerted by individuals of differing strengths is not standardized. These studies also did not measure movement of the torso. Movement of the torso relative to the head would be expected to produce shearing forces on the neck and could be an important concern.

We chose to use a 90-degree tilt when evaluating immobilization because this is a procedure that is often employed when a patient with an unsecured airway begins to vomit. Our study design did not permit measurement of flexion or extension of the neck. This may be why we were unable to show a benefit from a rigid cervical collar. In one previous study, the cervical collar, when used with tape and sandbags, prevented only extension of the neck but did not significantly reduce movement in other directions.

Although the differences in movement of various parts of the body were often statistically significant, the clinical importance is probably minimal. It is likely that there is substantially more movement of the spine during extrication and placement of the patient on the immobilization device. Significant movement of the lumbar spine, for example, has been noted while using the logrolling maneuver.

Regardless of the methodology used, this study suffers from the same drawbacks of previous efforts to investigate spinal immobilization. The fact that normal volunteers with no spinal injuries were used limits our conclusions. Clearly, a large clinical study evaluating the effectiveness of spinal immobilization in preventing further injury in patients with spinal injuries is needed. Given the relative infrequency of these injuries and the difficulty in collecting accurate prehospital data, such a study may never be done. In the absence of such a study, new methods for immobilization can only be compared to time-honored devices such as the rigid backboard. If new devices can achieve similar degrees of immobilization with more comfort for the patient, they may represent an improvement in patient care.

It should also be noted that this study was conducted in a very controlled setting. Clearly, a field study would be helpful in evaluating both devices with respect to other factors that may affect the usefulness of each device. Such factors might include use in extrication, durability, and ease of application in a variety of settings.

Although the vacuum splint compared favorably to the backboard in this study, it has some drawbacks which should be mentioned. First, it is more expensive than a wooden backboard. This is, however, a piece of equipment that may be used frequently and is much less expensive than many other pieces of prehospital equipment that are used only rarely. Second, it does not fit into the standard long, narrow backboard compartment of an ambulance. Alternate methods for storing the device, however, should not be a major problem.

One final point should be made with respect to vacuum splint devices. Even with all of the air removed from the device, they are not rigid enough to serve as an extrication device in some situations. Indeed, traditional rigid backboards serve two functions in prehospital care. In addition to immobilization, they function as large spatulas to lift and move patients. If vacuum splints are to gain widespread acceptance, techniques for extrication of patients onto these devices must be developed and evaluated.

CONCLUSIONS

With respect to the variables evaluated in this study, the vacuum splint seems to be a reasonable alternative to traditional spinal immobilization using a rigid backboard. In addition to being significantly more comfortable, immobilization and speed of application are similar to a traditional rigid backboard. The addition of a rigid cervical collar added little to immobilization on either the vacuum splint or the rigid backboard in this study.

REFERENCES