The continued burden of spine fractures after motor vehicle crashes

Clinical article

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Object. Spine fractures are a significant cause of morbidity and mortality after motor vehicle crashes (MVCs). Public health interventions, such as the National Highway Traffic Safety Administration’s Federal Motor Vehicle Safety Standards, have led to an increase in automobiles with air bags and the increased use of seat belts to lessen injuries sustained from MVCs. The purpose of this study was to evaluate secular trends in the occurrence of spine fractures associated with MVCs and evaluate the association between air bag and seat belt use with spine fractures.

Methods. Using the Crash Outcome Data Evaluation System, a database of the police reports of all MVCs in Wisconsin linked to hospital records, the authors studied the occurrence of spine fractures and seat belt and air bag use from 1994 to 2002. Demographic information and crash characteristics were obtained from the police reports. Injury characteristics were determined using International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) hospital discharge codes.

Results. From 1994 to 2002, there were 29,860 hospital admissions associated with automobile or truck crashes. There were 20,276 drivers or front-seat passengers 16 years of age and older who were not missing ICD-9-CM discharge codes, seat belt or air bag data, and who had not been ejected from the vehicle. Of these, 2530 (12.5%) sustained a spine fracture. The occurrence of spine fractures increased over the study period, and the use of a seat belt plus air bag, and of air bags alone also increased during this period. However, the occurrence of severe spine fractures (Abbreviated Injury Scale Score \( \geq 3 \)) did not significantly increase over the study period. The use of both seat belt and air bag was associated with decreased odds of a spine fracture. Use of an air bag alone was associated with increased odds of a severe thoracic, but not cervical spine fracture.

Conclusions. Among drivers and front-seat passengers admitted to the hospital after MVCs, the occurrence of spine fractures increased from 1994 to 2002 despite concomitant increases in seat belt and air bag use. However, the occurrence of severe spine fractures did not increase over the study period. The use of both seat belt and air bag is protective against spine fractures. Although the overall increased occurrence of spine fractures may appear contrary to the increased use of seat belts and air bags in general, it is possible that improved imaging technology may be associated with an increase in the diagnosis of relatively minor fractures. However, given the significant protective effects of both seat belt and air bag use against spine fractures, resources should continue to be dedicated toward increasing their use to mitigate the effects of MVCs. (DOI: 10.3171/SPI.2008.10.08279)

Key Words • air bag • epidemiology • motor vehicle crash • restraint • seat belt • spine fracture

M otor vehicle crashes are a major cause of spinal injury in the US.\(^1\) Public health interventions such as the National Highway Traffic Safety Administration’s Federal Motor Vehicle Safety Standards have led to an increase in automobiles with air bags, and mandatory seat belt legislation and education have been targeted to increase use of restraints to lessen injuries sustained from MVCs.\(^2\) Seat belt and air bag use are associated with a reduction in mortality rate after MVCs,\(^4\) as well as varying degrees of protection against injuries by body region (head, thorax, and abdomen).\(^7\) These protective effects against occupant injuries may also have resulted in a decrease in the occurrence of spinal fractures. Claytor et al.\(^3\) previously reported a protective effect of seat belts and the use of both seat belts and air bags against cervical spine fractures in a case-control study using the National Automotive Sampling System database. Reed and colleagues\(^8\) found an increase in the incidence of 1990 AIS Score 1 cervical spine injuries with the use of a seat belt alone or with a seat belt plus an air bag. However, other studies have suggested that use of an air bag

Abbreviations used in this paper: AIS = Abbreviated Injury Scale; CODES = Crash Outcomes Data Evaluation System; ICD-9-CM = International Classification of Disease, 9th Revision, Clinical Modification; MVC = motor vehicle crash.
Spine fractures and MVCs

without a seat belt might predispose patients to different patterns of injuries. Donaldson et al. found that drivers who used an air bag without a seat belt had a significantly higher incidence of cervical fractures compared with those who used both a seat belt and an air bag.

Using the Wisconsin CODES database, a population-based database linking police reports of MVCs to hospital discharge data, we sought to determine whether the occurrence of spine fractures associated with MVCs had changed over time among drivers and front-seat passengers admitted to the hospital after a MVC. We also sought to evaluate the association between air bag and seat belt use with spine fractures among this study population.

Methods

Data Source

De-identified data were obtained from the Wisconsin CODES database from 1994 through 2002. The Wisconsin CODES database is funded by the National Highway Traffic Safety Administration through the Wisconsin Department of Transportation. The Wisconsin CODES database is a multiagency collaborative effort to collect information on all MVCs reported to the police in the state of Wisconsin. Crash information from the Department of Transportation is linked with Wisconsin Hospital Discharge data at the Center for Health Systems Research and Analysis. Probabilistic linkage techniques are used to combine data from both data sets using likelihood weights (http://www.chsra.wisc.edu/codes). Data are then de-identified for public use. The database does not include information about people who are injured in Wisconsin but transferred out of state for medical care, people in unreported crashes, and people who have insufficient crash records for linkage with hospital discharge data; this is estimated to result in nondifferential missing hospitalization data for 20% of crashes. Seat belt use data are obtained from police crash reports. The present study was approved by the Medical College of Wisconsin Institutional Review Board.

Study Design

We performed a retrospective cohort study of patients hospitalized after MVCs with and without spine fractures. Cases were included if patients were drivers or front-seat passengers in automobile or truck crashes reported to the police in the state of Wisconsin. We included drivers and front-seat passengers because these people would be the most likely to have exposure to seat belts and air bag deployment. Each case was a hospital discharge, so patients could be included more than once if they were evaluated in the hospital after > 1 MVC between 1994 and 2002. Cases were excluded if the patient was younger than 16 years of age or patients 16 years of age and older. Restraint type and use also differs significantly by age. We excluded patients who used a lap belt, and patients who were ejected from the vehicle since they are known to incur different injury patterns than patients who are not ejected. Cases were also excluded if they were missing all hospital discharge diagnosis codes. Fatalities occurring in the hospital were not excluded.

Spine fractures were defined using ICD-9-CM diagnosis codes. Cervical spine fractures were defined using the following codes: 805.00–805.08, 805.10–805.18, 806.00–806.08, 806.10–806.18, 839.00–839.08, and 839.10–839.18. Thoracic and lumbosacral fractures were defined similarly, with diagnosis codes 805.2–805.7, 806.20–806.79, 839.20–839.31, 839.42, and 839.52.

The CODES database contains the following data elements that were included in our study: age, sex, type of vehicle, patient position in vehicle, seat belt use, air bag deployment, year of admission, location of crash, severity of crash as estimated by police, hospital length of stay, discharge disposition, and hospital discharge ICD-9-CM diagnosis codes. These variables are recorded in the CODES database and are gathered from either police reports or hospital discharge records. Restraint classifications were based on police reports of seat belt use and air bag deployment. We categorized these as seat belt only, air bag deployment only, seat belt use and air bag deployment, and no seat belt use or air bag deployment. International Classification/AIS MAP-90 software was used to convert ICD-9-CM codes to AIS scores.

Statistical Analysis

Statistical analysis was performed with commercially available software (Stata version 9.2, StataCorp LP). The chi-square test and Mann-Whitney U-test were used, and multiple logistic regression was used to evaluate secular trends in spine fractures and seat belt and air bag use, adjusting for age, sex, severity of damage to the vehicle according to the police report, location of crash, and type of vehicle, with 1994 as the reference year. Multiple logistic regression was also used to study the association between spine fractures and seat belt or air bag use compared with the rest of the study population, adjusting for age, sex, severity of damage to the vehicle by police report, location of crash, type of vehicle, and year of study. Statistical significance was defined as p < 0.05.

Results

From 1994 through 2002, there were 29,860 hospital admissions associated with automobile or truck crashes reported to the police in Wisconsin. Of these, 2784 admissions were for patients who were neither drivers nor front-seat passengers, 2299 were completely or partially ejected from the vehicle, and 971 were younger than 16 years of age. In 78 cases the patients’ charts lacked hospital discharge diagnosis codes, 2830 were missing seat belt data or were wearing a lap belt only, and 622 were missing air bag data, leaving a final sample size of 20,276 hospital admissions (Fig. 1).

There were 2530 spine fractures (12.5%) identified among 20,276 admissions. Of these, there were 1067 cervical fractures, 565 thoracic fractures, and 1034 lumbosacral fractures. There were 82 patients (8%) with a cervical spine fracture who also had a thoracic and/or lumbosacral fracture. Of the patients with a thoracic spine fracture, 54 (10%) also had a lumbosacral fracture.
Severity of Spine Fractures

The majority of spine fractures (2059 or 81%) were classified as AIS Score 2. Overall 8% of all spine fractures were classified as severe (202 fractures; ICD Map-90 AIS Scores ≥ 3). By cervical, thoracic, or lumbosacral level, 131 (12%), 48 (9%), and 36 (4%), respectively, were classified as ICD Map-90 AIS Scores ≥ 3.

Patient Demographics and Injury Characteristics

In comparison with patients without spine fractures, a higher proportion of patients with spine fractures was male, in a truck as opposed to an automobile, and sustained a crash in a rural location. Patients with a spine fracture also had a higher Injury Severity Score (8 vs 5 in patients without a spine fracture), a longer hospital stay (median 5 days vs 3 days for patients without a spine fracture), and were less commonly discharged home (65 vs 75% of patients without a spine fracture; Table 1).

Seat Belt and Air Bag Use

Patients with spine fractures more commonly wore a seat belt only compared with patients without spine fractures (51 vs 48%; p = 0.04). More patients without spine fractures were restrained by a seat belt and an air bag compared with those with spine fractures (14 vs 10%; p < 0.01). We did not find a significant difference in use of an air bag without seat belt among patients with or without spine fractures. Overall, 33% of patients without a spine fracture were completely unrestrained by seat belt or air bag versus 34% of patients with a spine fracture (Table 2).

Secular Trends in the Occurrence of Spine Fractures and Seat Belt and Air Bag Use

The occurrence of spine fractures increased by year over the study period even after adjustment for age, sex, seat belt and air bag use, type of vehicle, severity of damage to the vehicle according to police report, and location of crash (adjusted OR 1.04, 95% CI 1.02–1.05, p < 0.01; Table 3). However, the occurrence of severe spine fractures (ICD Map-90 AIS Score ≥ 3) did not increase significantly over the study period (adjusted OR 1.03, 95% CI 0.98–1.09, p = 0.2).
The use of seat belt plus air bag or air bag only increased significantly over the study period, while the use of a seat belt only decreased over the study period (Fig. 2).

**Risk of Spine Fracture and Seat Belt and Air Bag Use**

Use of both a seat belt and an air bag was associated with decreased odds of a fracture (adjusted OR 0.67, 95% CI 0.57–0.79, p < 0.01) compared to all other study subjects. Likewise, use of a seat belt and an air bag was also protective against cervical and thoracic spine fractures (cervical adjusted OR 0.54, 95% CI 0.42–0.70, p < 0.01; thoracic adjusted OR 0.68, 95% CI 0.49–0.93, p = 0.02), but not for lumbosacral fractures. In comparison to all other study subjects, use of a seat belt only was associated with increased odds of sustaining a spine fracture even after adjustment for age, sex, severity of damage to the vehicle by police report, location of crash, type of vehicle, and year of study (adjusted OR 1.17, 95% CI 1.08–1.28, p < 0.01; Table 4). Likewise, use of an air bag alone conferred no protection against spinal fractures.

For severe spine fractures (ICD Map-90 AIS Scores ≥3), only the use of both a seat belt and an air bag was associated with decreased odds of sustaining a severe spine fracture even after adjustment (OR 0.41, 95% CI 0.23–0.76, p < 0.01). No other associations were statistically significant. Likewise, for severe fractures of the cervical spine, the association remained the same (adjusted OR 0.19, 95% CI 0.07–0.52, p < 0.01). The use of an air bag alone was not associated with significantly increased odds of sustaining a cervical spine fracture. In contrast, use of an air bag alone was significantly associated with increased odds of sustaining a severe thoracic spine fracture, even after adjustment (adjusted OR 3.2, 95% CI 1.42–7.23, p < 0.01). Finally, for severe lumbar fractures, the use of a seat belt only was associated with decreased odds of sustaining a severe lumbar fracture (unadjusted OR 0.46, 95% CI 0.23–0.94, p = 0.03), but this was not

**TABLE 1: Characteristics of patients admitted with spine fractures compared to those without spine fractures**

<table>
<thead>
<tr>
<th>Admitted Patient &amp; MVC Characteristics</th>
<th>w/o Spine Fracture (17,746 admissions)</th>
<th>w/ Spine Fracture (2530 admissions)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>median age in yrs (IQR)</td>
<td>40 (25–63)</td>
<td>39 (26–58)</td>
<td>0.04</td>
</tr>
<tr>
<td>male (%)</td>
<td>9673 (55)</td>
<td>1444 (57)</td>
<td>0.02</td>
</tr>
<tr>
<td>driver (%)</td>
<td>14,174 (80)</td>
<td>2001 (79)</td>
<td>NS</td>
</tr>
<tr>
<td>in a truck (%)</td>
<td>2563 (14)</td>
<td>487 (19)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>severe vehicle damage (%)</td>
<td>14,200 (80)</td>
<td>2021 (80)</td>
<td>NS</td>
</tr>
<tr>
<td>rural location of crash (%)</td>
<td>10,955 (62)</td>
<td>1894 (75)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>median ISS score (IQR)</td>
<td>5 (2–10)</td>
<td>8 (4–13)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>in-hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>median LOS, days (IQR)</td>
<td>3 (1–6)</td>
<td>5 (2–9)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>died in hospital (%)</td>
<td>457 (3)</td>
<td>64 (3)</td>
<td>NS</td>
</tr>
<tr>
<td>discharged home (%)</td>
<td>13,352 (75)</td>
<td>1641 (65)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

* IQR = interquartile range; ISS = Injury Severity Scale; LOS = length of hospital stay; NS = not significant (p > 0.05).

**TABLE 2: Seat belt and air bag use and spine fractures**

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>No. of Admissions</th>
<th>No Seat Belt or Air Bag (%)</th>
<th>Seat Belt Only (%)</th>
<th>Seat Belt &amp; Air Bag (%)</th>
<th>Air Bag Only (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>17,746</td>
<td>5805 (33)</td>
<td>8597 (48)</td>
<td>2495 (14)</td>
<td>849 (5)</td>
</tr>
<tr>
<td>any spine fracture†</td>
<td>2530</td>
<td>867 (34)</td>
<td>1281 (51)</td>
<td>256 (10)</td>
<td>126 (5)</td>
</tr>
<tr>
<td>cervical</td>
<td>1067</td>
<td>385 (36)</td>
<td>543 (51)</td>
<td>89 (8)</td>
<td>50 (5)</td>
</tr>
<tr>
<td>thoracic</td>
<td>565</td>
<td>208 (37)</td>
<td>270 (48)</td>
<td>58 (10)</td>
<td>29 (5)</td>
</tr>
<tr>
<td>lumbosacral</td>
<td>1034</td>
<td>326 (32)</td>
<td>533 (52)</td>
<td>120 (12)</td>
<td>55 (5)</td>
</tr>
</tbody>
</table>

* Numbers are rounded and may not add to 100%.
† Because there were concomitant fractures in the cervical, thoracic, and/or lumbosacral spine in some cases, the total number of admissions for spinal fractures is not the sum of admissions for cervical, thoracic, and lumbosacral fractures.
significant after adjustment (adjusted OR 0.52, 95% CI 0.27–1.03, p = 0.06).

**Discussion**

Despite increases in the use of seat belts and air bags together and of air bags only, the occurrence of spine fractures among drivers and front-seat passengers in MVCs increased between 1994 and 2002, even after adjustments for patient demographics and crash characteristics. Overall, we found that spine fractures affected 12.5% of the study population. Most fractures were cervical or lumbar, and 8% of patients with a cervical spine fracture also had a thoracic or lumbar fracture. Although most spine fractures were of moderate severity (ICD Map-90 AIS Score ≥ 3), and the majority of severe spine fractures were in the cervical spine (12%). Of note, the occurrence of severe spine fractures did not significantly increase over the study time period.

In comparison to other study subjects, patients with spinal fractures were also more likely to be wearing a

**TABLE 3: Secular trends in the occurrence of spine fractures and seat belt and air bag use, 1994–2002**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Unadjusted OR</th>
<th>95% CI</th>
<th>p Value</th>
<th>Adjusted OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine fracture†</td>
<td>1.03</td>
<td>1.02–1.05</td>
<td>&lt;0.01</td>
<td>1.04</td>
<td>1.02–1.05</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AIS Scores ≥3†</td>
<td>1.02</td>
<td>0.97–1.08</td>
<td>NS</td>
<td>1.03</td>
<td>0.98–1.09</td>
<td>NS</td>
</tr>
<tr>
<td>Seat belt only‡</td>
<td>0.93</td>
<td>0.92–0.94</td>
<td>&lt;0.01</td>
<td>0.93</td>
<td>0.92–0.94</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Air bag deployed‡</td>
<td>1.26</td>
<td>1.23–1.29</td>
<td>&lt;0.01</td>
<td>1.26</td>
<td>1.23–1.30</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Belt used &amp; air bag deployed‡</td>
<td>1.28</td>
<td>1.26–1.30</td>
<td>&lt;0.01</td>
<td>1.29</td>
<td>1.27–1.32</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

* The reference year is 1994.
† Simultaneously adjusting for age, sex, seat belt and air bag use, severity of damage to the vehicle according to the police report, location of crash, and type of vehicle.
‡ Simultaneously adjusting for age, sex, severity of damage to the vehicle according to the police report, location of crash, and type of vehicle.

**Fig. 2.** Graph of trends in spine fractures and seat belt and air bag use among drivers and front-seat passengers admitted to the hospital after MVCs in Wisconsin, 1994–2002.
TABLE 4: Spine fractures and the use of seat belt and air bags*

<table>
<thead>
<tr>
<th>Seat Belt/Air Bag Use</th>
<th>Unadjusted OR</th>
<th>95% CI</th>
<th>p Value</th>
<th>Adjusted OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>seat belt only</td>
<td>1.09</td>
<td>1.00–1.19</td>
<td>0.04</td>
<td>1.17</td>
<td>1.08–1.28</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>air bag only</td>
<td>1.04</td>
<td>0.86–1.26</td>
<td>NS</td>
<td>1.05</td>
<td>0.86–1.29</td>
<td>NS</td>
</tr>
<tr>
<td>seat belt &amp; air bag</td>
<td>0.69</td>
<td>0.59–0.80</td>
<td>&lt;0.01</td>
<td>0.67</td>
<td>0.57–0.79</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

* Simultaneously adjusting for age, sex, severity of damage to the vehicle according to police report, location of crash, type of vehicle, and year of study. The reference population is all other study subjects.

Spine fractures and MVCs

Our findings support other reports of the protective effects of the combined use of a seat belt and air bag against spine fractures. However, we did find an association between severe thoracic spine fractures and the use of an air bag only.

It is possible that increased utilization of CT scanning and improvements in radiological techniques may have increased the diagnosis and ICD-9-CM coding of minor fractures. Goldberg et al. studied patients with blunt trauma who underwent cervical spine radiography and found that 818 (2.4%) of 34,069 enrolled patients sustained 1,496 cervical spine fractures. Of these fractures, about one-third were considered clinically insignificant. Unfortunately, ICD-9-CM codes do not allow for great specificity in assessing the severity of fracture, but these codes can be converted to AIS scores. Using the International Classification/AIS MAP-90 software, we found that the occurrence of severe spine fractures (AIS Scores ≥ 3) did not increase over the study period (adjusted OR 1.03, 95% CI 0.98–1.09, p = 0.2). This finding suggests that some of the increase in the occurrence of spine fractures over time may be related to an increase in the diagnosis of less severe fractures. Using the National Automotive Sampling System database and clinical data, Yoganandan et al. noted a decrease in the occurrence of cervical spine injuries of AIS scores ≥ 3 with restraint use. Nevertheless, in the current study, the Injury Severity Scale score and length of stay were greater in patients with spine fractures than in those without, suggesting that in general, patients with spine fractures sustained more severe injuries. A longitudinal database containing imaging studies and specific details concerning spine fractures would be better suited to studying changes in patterns of spine fractures over time.

Study Limitations

The limitations of this study include the CODES data set, which contains only MVCs reported to the police in the state of Wisconsin. People who died at the scene and those who were not admitted to the hospital were not included in this data. Our study population was also limited to adult drivers and passengers who were not ejected from the vehicle, so the results may not be generalizable to the overall population. In addition, the database does not contain information on persons who sustain MVCs but are not admitted to the hospital. We limited our conclusions to the data available. Use of these data may underestimate the protective effects of seat belts and air bags if more MVC occupants avoid hospitalization because of these protective measures. Nevertheless, the CODES database contains population-based information linked to hospital discharge data and therefore, provides a more generalizable estimate of spine fractures for the overall population of drivers and front-seat passengers who are admitted to the hospital after an MVC. Further work might use data from other states that participate in the CODES network.

The CODES database contains ICD-9-CM diagnosis codes that lack specificity or information about the type and severity of the spine fracture. Diagnosis of a spine fracture might also differ since radiology techniques (radiography, CT scanning, and MR imaging) have different sensitivities for detecting injury and may be used differently in hospitals in Wisconsin. The CODES database contains up to 5 hospital discharge ICD-9-CM diagnosis codes per patient. It is possible that patients with multiple injuries and a cervical spine fracture may not have had their cervical fracture listed in the top 5 discharge diagnoses. However, the increased length of in-hospital stay and the number of in-hospital deaths suggest that the spine injuries listed among the 5 discharge diagnoses had a significant impact on patient care.

We used ICD Map-90 to calculate the AIS and Injury Severity Scale scores in this study, and used severe vehicle damage reports by police as a proxy for the severity of the crash because change in velocity (∆V) was not available. The direction and force of the crash was not well documented in the CODES database. The National Maximum Speed Law was repealed by Congress in 1995. In Wisconsin, both rural and urban interstate speed limits were increased on December 8, 1995, to 75 and 60 miles per hour, respectively. However, direct knowledge
of the vehicle model and $\Delta V$ would provide better details about crash characteristics. Finally, the use of seat belts is recorded by police, and a mandatory seat belt law in Wisconsin was enacted in 1987. Because of the mandatory seat belt law, we might expect alert patients to overreport their seat belt use to the police, and thereby possibly decrease an association between seat belt use and the reduced occurrence of spine fractures. However, we found a strong association between combined seat belt and air bag use and decreased odds of a spine fracture.

Conclusions

Among drivers and front-seat passengers admitted to the hospital after qualifying MVCs, the occurrence of spine fractures associated with MVCs increased between 1994 and 2002 despite concomitant increases in seat belt and air bag use. However, the occurrence of severe spine fractures in this study population did not increase over this time period. The use of both a seat belt and an air bag was associated with decreased odds of sustaining a spine fracture. Although the increased occurrence of spine fractures in our study population may appear contrary to the increased use of seat belts and air bags in general, it is possible that improved imaging technology may be associated with an increase in the diagnosis of relatively minor fractures, or that more drivers and front-seat passengers in MVCs may be avoiding hospitalizations because of the protective effects of seat belts and air bags. However, the limitations of the CODES data set prevent us from drawing definitive conclusions about these possibilities.

Given the significant protective effects of both seat belt and air bag use against spine fractures, resources should continue to be dedicated toward increasing their use to mitigate the effects of MVCs. Further research into the patterns of spine fractures should include more specific details such as imaging characteristics or clinical data to better classify the severity of injury.

Disclosure

Unrestricted research support was provided by EBI Medical, Inc., and Abbott Spine.

Acknowledgments

The authors acknowledge Prakash Laud, Ph.D., Clare Guse, M.S., Medical College of Wisconsin Injury Research Center, and Wayne Bigelow, Wisconsin Department of Transportation, for their assistance.

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Manuscript submitted June 6, 2008.
Accepted October 16, 2008.
A portion of this paper has been presented orally at the Rachidian Society Annual Meeting 2007.
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Spine Fractures in Motor Vehicle Crashes are Preventable by the Combination of Seat Belts and Air Bags

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To The Editor: Wang et al.6 have performed a major service to the community by carefully examining the relationship between seat belts and air bags and the incidence of spine fractures in motor vehicle crashes (MVCs) in Wisconsin. They studied the records of almost 30,000 crash victims 16 years of age and older admitted to Wisconsin hospitals after car or truck crashes from 1994 to 2002 and determined the number of those wearing seat belts and using air bags. Complete data were available for about 20,000 cases, and the authors found that 12.5% had spine fractures; the combination of seat belts and air bags provided the best protection against spine fractures, including the most severe fractures. Patients with both seat belts and air bags had fewer spinal fractures than those with neither seat belts nor air bags, or those with only seat belts or only air bags. The study provides a clear message about the value of seat belts, an active type of injury-prevention measure dependent on the driver or passenger to use it, and air bags, a passive measure not requiring intentional activation. Incredibly, only 14% of drivers and front-seat occupants who crashed in Wisconsin between 1994 and 2002 were protected by the combination of seat belts and air bags. The authors found that the incidence of spine fractures actually increased from 1994 to 2002, although they correctly pointed to the improved diagnosis of spinal fractures by modern measures such as CT to explain at least some of the increase.

It is commendable that Wang’s group6 performed this extensive, labor-intensive, epidemiological study of trauma patients, and it is appropriate for neurosurgeons to be at the forefront in trauma scholarship, especially in determining best practices for injury prevention. Neurosurgeons can contribute to the prevention of catastrophic trauma by examining strategies to combat the current highway carnage. Motor vehicle crashes are still the number one cause of both brain and spine injuries in many countries.7,9 In this study, Wang and colleagues6 clearly showed that the best practice is to use both seat belts and air bags, and this combination was recently found to be superior to either alone for the prevention of brain injuries as well.1,11

The Wisconsin study provides an excellent opportunity to examine the entire spectrum of injury-prevention measures targeted toward MVCs. The following briefly examines the “who, where, when, and why” of MVCs, the methods in place to obtain and collect crash data, and the specific injury-prevention measures, including seat belts and air bags. Prevention of MVCs can usefully be discussed in terms of the 5 E’s of injury prevention: Epidemiology, Engineering, Education, Enforcement/Legislation, and Evaluation of Effectiveness.

Epidemiology of Spine Fractures in MVCs

To prevent trauma, it is essential to know exactly how injuries occur, to whom, and at what frequency. Unfortunately, such data is extremely costly to record, collect, and analyze. It is a tribute to the National Highway Traffic Safety Administration (NHTSA) that a system of recording crash data was in place for the authors to use, and that the State of Wisconsin had taken steps through the Wisconsin Crash Outcomes Data Evaluation System (CODES) to relate police records to hospital discharge data based on the International Classification of Diseases (ICD) utilizing the ICD-9-CM version.12 This essential linkage of the 2 data sets was facilitated by the Wisconsin Center for Health System Research.1 It is uncertain how many states, provinces, or countries have this linkage capability.1 Ideally, national data should be similarly linked so that the full extent of spinal fractures in each country can be determined. For example, this data may be useful for bringing recalcitrant areas up to national or international standards. Also, it should be noted that there are still missing links in the Wisconsin data retrieval as pointed out by Wang et al.6 Their 12.5% incidence of spinal fracture underestimates the true incidence of spinal fractures in MVCs because it does not include deaths at the scene or en route to the hospital, victims ejected from the vehicles, back seat passengers, some multiple trauma cases (related to a coding restriction), and those younger than 16 years old. Nevertheless, the 12.5% figure is very important and should be made known to all retrieval and emergency department personnel who have the responsibility to detect spine fractures in crash victims. Astoundingly, at least 1 in 8 will have 1 or more spine fractures.

Engineering to Reduce Spine Fractures in MVCs

The public has benefited enormously from the efforts of engineers to design safer motor vehicles. However, there are still far too many injured victims, and the 12.5% who sustained spinal fractures indicates an enormous toll. What additional safe engineering strategies can be instituted to reduce this figure? Unfortunately, passive seat belt deployment has not been practical to date, and as noted by the authors, 38% of those injured
in MVCs in Wisconsin did not use a seat belt. Thus, further steps should be taken to develop new methods of passive seat belt activation, such as deployment by ignition. There are many other engineering strategies such as breathalyzer-linked ignition to eliminate inebriated drivers, automatic collision warning sensors, video cameras, and avoidance of distractions such as ignition-deactivated mobile telephones. Exact crash changes in velocity and time (ΔV and ΔT) should be available for every crash, and then we would know the true effect of speeding on crash incidence. Event data recorders (EDRs, the “black box” of airplanes), which are capable of recording speed, air bag, seat belt, and braking data, should be mandated for all vehicles.8

_Education and Knowledge Translate to a Reduction in Spine Fractures in MVCs_

Neurosurgeons should ensure that the knowledge gained in neurotrauma-related trauma research, whether clinical or basic, is made known to the public, and translated into action. Neurosurgeons are ideally positioned to serve society in this way through the ThinkFirst organization, the international injury-prevention program initiated by neurosurgeons in the US in 1986, then in Canada in 1992, and more recently in several other countries. ThinkFirst programs in schools and in communities disseminate injury-prevention messages to the public about MVCs, with specific recommendations such as booster seats for children, and greater use of the combination of seat belts and air bags.4,10

_Effortment and Legislation to Reduce Spine Fractures in MVCs_

Education alone will not suffice for producing a major increase in the 14% who now use both seat belts and air bags. Legislation and strict enforcement would help to raise this figure to near 100%. The Wisconsin Department of Transportation lists speeding and alcohol as important factors in crashes.12 Determination of the true influence of speeding requires more accurate recording techniques, such as EDR. It is highly likely that the increase in the speed limits in Wisconsin in 1995 was an important cause of the increase in the incidence of spinal fractures between 1994 and 2002. Speed has always been a major factor in MVCs in Wisconsin as acknowledged by the Wisconsin Department of Transportation.12 In my view a speed limit of 75 miles per hour is too high for the average brain and spine and the average road, anywhere! It is highly likely that the preponderance of rural sites in the Wisconsin crash data is also directly linked to speed. ThinkFirst and neurosurgeons should build a coalition to advocate for reduced speed limits, mandatory use and enforcement of seat belts and air bags, and deployment of EDRs in all cars and trucks.

_Evaluation of Effectiveness of Injury-Prevention Measures to Reduce Spine Fractures in MVCs_

Injury-prevention programs to reduce death and disability caused by trauma must be evaluated to ensure that the measures are working. For example, measures taken to increase the use of the combination of seat belts and air bags must be assessed in terms of the incidence of spine fractures and the incidence of the use of seat belts and air bags. Accurate evaluation requires accurate crash data, and ideally this means neurotrauma registries. The reduction of neurotrauma is so important that state and national neurotrauma registries should be instituted. Registries facilitate epidemiological studies to monitor crash data, and that is essential for establishing effectiveness of injury-prevention measures. Approximately half of trauma-related deaths are due to head injuries,2 and together brain and spinal cord injury account for a significant portion of the cost of trauma care.1 The neurosurgery group in Wisconsin would be ideally suited to direct the development of a state neurotrauma registry, and then perhaps advocate for a national neurotrauma registry. Unfortunately, registries and effectiveness studies are extremely costly, but then so are road deaths and disability.

It is time to institute more effective strategies to control MVCs.

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We thank Dr. Tator for his thoughtful comments and perspective. We agree that neurosurgeons play a key role in studying trauma epidemiology, prevention, and outcome in conjunction with a multidisciplinary team, and that our involvement includes helping to translate that knowledge into public policy and preventative strategies.

Dr. Tator also brings up another important issue—that of tracking neurotrauma on a statewide or national basis using neurosurgical expertise to help design such a registry. Current registries are not comprehensive and often include large amounts of missing data. For example, the Crash Outcome Data Evaluation System (CODES) database we used in our study is missing information about restraints and has limited information regarding clinical characteristics except for ICD-9-CM codes. This missing information may often lead to uncertain conclusions about the efficacy of strategies to prevent or treat injuries. Given that brain and spinal cord trauma are major contributors to death and disability, registries using a multidisciplinary approach, such as the Crash Injury Research Engineering Network (CIREN), are excellent examples of integrating accurate crash data with clinically relevant data. Ideally, these registries would then be used to help focus research and changes in public policy. Although progress in injury prevention has been made, more work needs to be done to reduce the burden of these injuries.

(DOI: 10.3171/SPINE.2008.10.08706)