Study Design: Retrospective case series.

Objectives: To describe an injury mechanism and a series of patients with spine fractures after passing over speed humps in a motor vehicle.

Summary of Background Data: The use of speed humps as an effective measure to reduce the rate of traffic accidents is still a matter of discussion. Furthermore, their use in mass transport routes may cause spine injuries among passengers in motor vehicles.

Methods: Review of the database in our medical records, identifying all the patients with spine fractures that occurred after passing over speed humps while in a motor vehicle, from January 1, 1997 to April 30, 2008 in the Hospital del Trabajador de Santiago, Chile.

Results: Of a sample of 46 patients with 52 fractures—none of them with neurologic impairment—37 female patients (80.4%) and 9 male patients (19.6%) with an average age of 48.5 years (16 to 70 y), 67.4% (31 of 46) presented comorbidities. Six patients presented 2 spine fractures, all of them at adjacent levels. Forty-four individuals (95.7%) were injured in a bus: 42 of 44 patients (95.5%) were seated on the last row, whereas the remaining 2 patients were bus drivers. All patients had type A Association for Osteosynthesis/Association for the Study of Internal Fixation fractures, 30/52 (57.7%) subtype A1 and 20/52 (38.5%) subtype A3. L1 was the most frequently fractured vertebra (23/52, 44.2%), followed by T12 (11/52, 21.2%). Ten patients (21.7%) required surgical treatment. The average time out of work was 104.3 days; 3 patients (6.5%) received workers' compensation for chronic lumbar pain. The mean follow-up time was 78.6 months (24 to 159).

Conclusions: Seating in a motor vehicle, particularly on the last row in a bus, as it passes over a speed hump may cause severe traumatic spine injuries. These fractures occur more frequently at the thoracolumbar junction and treatment may require surgery.

Key Words: spine fracture, speed hump, injury mechanism

The use of different devices to reduce the circulation speed of motor vehicles—particularly in residential areas—has been advocated as an effective measure to reduce the rate of traffic accidents. Some investigators have shown that circulation speeds are reduced by their use, but their role in the incidence of accidents and pedestrian protection is still a matter of discussion. Speed humps (Fig. 1) have been used in Chile with this aim since 1996, after the promulgation of a supreme decree by the government. Speed humps have, since then, increased exponentially throughout the country, especially in the capital, Santiago. Unfortunately, speed humps are not always built according to regulations and vary from the original designs. In contrast and despite the fact that regulation has existed for several years in developed countries to avoid their use in mass transport routes, no such regulation exists in Chile. Speed humps can thus become dangerous elements for drivers and passengers, who have progressively presented serious injuries associated with their use. Bowrey et al reported in 1996 the first 2 cases of spine fractures that occurred after passing over a speed hump in a motor vehicle.
The objective of this study is to describe the injury mechanism and the characteristics of a series of patients with spine fractures after passing over a speed hump in a motor vehicle.

METHODS

We conducted a retrospective case study series. Data were obtained from the institutional database of medical records, identifying 46 patients who had been admitted to the Hospital del Trabajador de Santiago, Chile, for a spine fracture, that occurred after riding over a speed hump in a motor vehicle, from January 1, 1997 to April 30, 2008. Table 1 shows the demographic information of the study group. There were 37 female patients (80.4%) and 9 male patients (19.6%), with an average age of 48.5 years (16 to 70 y). All of the patients were injured in Santiago, the capital, and none of them had neurologic impairment. Thirty-one patients (67.4%) presented at least 1 comorbidity. A body mass index greater than 25 was the most frequent (15 patients, 32.6%), followed by bone metabolism disorders (osteoporosis, autoimmune pathologies, and hypothyroidism) in 11 patients (23.9%) and type 2 diabetes in 2 patients (4.3%).

Information about the type of vehicle, the patients’ seating position, fracture classification, level, and mode of treatment was also gathered in an electronic spreadsheet (Microsoft Excel 2008) to describe the characteristics of this set of patients.

In addition, a revision of the available literature was carried out to identify studies referring to this type of injuries.

RESULTS

Forty-four patients (95.7%) were injured in a bus, whereas only 2 cases occurred among car passengers (4.3%). Forty-two of the 44 patients (95.5%) traveling in a bus were passengers and all of them were seating on the last row when the vehicle passed over the speed hump. The remaining 2 patients (4.5%) were bus drivers.

Six patients (13%) presented 2 spine fractures at adjacent levels, adding up to a total of 52 fractures. According to the Association for Osteosynthesis (AO)/Association for the Study of Internal Fixation classification, all of the patients had type A fractures (compression injuries). The most common subtype was the A1 with 30 fractures (57.7%), followed by the A3 subtype with 20 cases (38.5%), whereas the remaining 2 fractures (3.8%) were classified as the A2 subtype. The most frequently fractured vertebra was L1 (23 of 52, 44.2%), followed by T12 (11 of 52, 21.2%). There were 9 L2 fractures (17.3%), 3 L3 fractures (5.8%), and 2 L4 fractures (3.8%). The remaining 4 cases were single T6, T7, T8, and T11 fractures (1.9% each). Figure 2 summarizes fracture distribution according to level and type of injury.

Considering the characteristics of the injuries and treatment protocols used at our institution,4 36 patients (78.3%) received conservative treatment, whereas the remaining 10 patients (21.7%) required surgery. Both the patients with A2 fractures were surgically treated to avoid the risk of pseudoarthrosis, as a result of disc herniation into the vertebral body. The remaining 8 surgically treated patients had A3 fractures which fulfilled at least 1 of the remaining AO Spine criteria for surgery, besides neurologic impairment: more than 50% of vertebral body wedging, more than 50% of spinal canal encroachment, and more than 20 degrees of segmental kyphosis.

Among the surgically treated patients, a pedicle instrumentation and posterolateral fusion was performed in 8 cases (1-level in 4 patients and 2-level in the rest), whereas the remaining 2 patients underwent a vertebroplasty of the injured vertebra. Five of the 8 fused patients (62.5%) required an additional procedure: 3 anterior reconstructions and 2 vertebroplasties. Anterior reconstruction was indicated in those patients with a significant vertebral body defect, considered as a potential failure risk for the posterior construct.

The average leave of absence from work was 104.3 days (median 94 d, range: 24 to 382 d), whereas 3 patients (6.5%) received workers’ compensation for chronic lumbar pain related to their injury. All of the compensated patients had A3 fractures and 2 of them were surgically treated (1 vertebroplasty and 1 posterior fusion that required an anterior reconstruction). The mean follow-up time was 78.6 months (median 70.5 mo, range: 24 to 159 mo).

| TABLE 1. Demographic Characteristics of the Study Group (n = 46) |
|-------------------|-------------------|
| **Mean age (y)**  | 48.5 (16-70)      |
| **Sex**           |                   |
| Female            | 37                |
| Male              | 9                 |
| **Comorbidities** |                   |
| Body mass index > 25 | 15                |
| Bone metabolism disorders | 11                |
| Type 2 diabetes   | 2                 |
| **Vehicle type and patient position** |     |
| Bus passengers    | 42                |
| Bus drivers       | 2                 |
| Car passengers    | 2                 |

FIGURE 2. Distribution according to fracture level and type (Association for Osteosynthesis/Association for the Study of Internal Fixation classification).
DISCUSSION

This study describes a unique injury mechanism. As the motor vehicle rises while it passes over the speed hump, a torque is generated. The magnitude of this torque is determined by the speed at which the vehicle impacts the speed hump and the distance between its application point and the center of rotation or pivot point (the axis of the wheel that remains in contact with the road; Fig. 3).

The torque generates a catapult effect on the vehicle’s suspension system. As a result, the passenger elevates suddenly from his seat, falling back abruptly and hitting the seat shortly because of gravity (Fig. 4).

There are only 2 earlier studies available reporting spine fractures associated to this injury mechanism. The first one is a British report, published in 1996, where the investigators present 2 patients with spine fractures (1 cervical and 1 lumbar) that occurred while the patients were traveling in a public transportation bus. The other is a Turkish article, published 9 years after the first one; reporting 5 more patients with this type of injury (4 lumbar and 1 cervical fractures). None of these publications refer to the injury mechanism. This way, this report constitutes the biggest case series of patients with spine fractures that occurred after passing over a speed hump in a motor vehicle and the only 1 that describes the injury mechanism.

This mechanism generates an axial force that is then absorbed by the spine, explaining the fact that all of the patients in this series presented compression fractures (Type A AO/Association for the Study of Internal Fixation).

Furthermore, all the patients traveling in a heavy vehicle were seating at one of the ends of the vehicle at the moment of injury, almost all of them on the last row. This observation is related to the fact that this seating position represents the furthest distance from the wheel that is not passing over the speed hump. These seats are also placed at a higher level because the motor of the vehicle is located underneath, thus implying a larger lever for the catapult effect described earlier.

In this case series, over 80% of the fractures occurred at the thoracolumbar junction, suggesting that the energy absorbed by the spine is concentrated in this segment. This could be explained by the fact that the thoracolumbar junction is a transition zone between the rigid thoracic spine and the mobile lumbar spine.

This mechanism may cause severe spine injuries, considering that 10 patients in this series required surgery (3 patients even required an anterior reconstruction).
and 3 were granted permanent disability compensation because of chronic lumbar pain.

One flaw of this study is the fact that, although both the design of the speed hump (profile and size) and the speed of the vehicle as it passes over it determine the magnitude of the force generated, these 2 elements were not evaluated, but they will be matter for new research.

Speed humps are used around the world in streets with mainly car traffic and high pedestrian density. Their implementation in mass transport routes may represent a risk, as these vehicles are bigger and have larger wheels, implying greater energy absorption mechanisms and exposing a larger number of people to injuries.

CONCLUSIONS

Seating in a motor vehicle while it passes over a speed hump may cause severe traumatic spine injuries. The injury mechanism involves a compressive axial force on the spine, produced by a catapult effect generated by the vehicle as it is driven over the hump. The magnitude of this force is determined by the speed and the size of the vehicle. These fractures occur more frequently at the thoracolumbar junction and their treatment may require surgery and prolonged time out of work.

REFERENCES