Spinal Fractures Caused by Speed Bumps

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ABSTRACT

Objective: To present a case series of spinal fractures in bus passengers caused by passing over speed bumps. **Materials and Methods:** A descriptive and retrospective study of a case series of thoracic and lumbosacral spinal injuries suffered by passengers as a result of vehicle impacts with speed bumps was conducted. Patients treated at two institutions from January 1, 2012 to January 1, 2023 were included. **Results:** 23 patients with vertebral injuries of the thoracolumbosacral spine were recorded: 14 women (60.9%) and 9 men (39.1%), average age 43 years (SD±12; range=25-62). Almost all of the patients were passengers (n=22, 95.7%) sitting in the last row of seats on the bus (n=20, 86.5%). A single case was documented involving the vehicle's driver. 29 spinal injuries were recorded, 28 thoracolumbar fractures (from T10 to L2; 96.6%) and 1 coccyx fracture (3.4%). The most frequently involved vertebra was L1 (n=16; 55%). The most severe fractures (A3/A4) were associated with surgical treatment (p=0.007) and a longer median hospital stay (p=0.005). **Conclusions:** Spinal injuries during vehicular impact with speed bumps are caused by an axial compression mechanism, with greater involvement of passengers who are located in the last row of seats. They primarily affect the thoracolumbar joint, with the L1 vertebra and exclusively one of the vertebral endplates being fractured most frequently.

Keywords: Thoracolumbar vertebral fracture; bus; speed bump; trauma.
Level of Evidence: IV

Fracturas vertebrales causadas por reductores de velocidad o "lomos de burro"

RESUMEN

Objetivo: Presentar una serie de casos de fracturas vertebrales en pasajeros de autobús asociadas al pasaje por reductores de velocidad. **Materiales y Métodos:** Se realizó un estudio descriptivo y retrospectivo de una serie de casos de lesiones vertebrales torácicas y lumbosacras sufridas por pasajeros a causa del impacto del vehículo con reductores de velocidad. Se incluyó a pacientes tratados en dos instituciones, entre el 1 de enero de 2012 y el 1 de enero de 2023. **Resultados:** Se registraron 23 pacientes con lesiones vertebrales de la columna toraco-lumbosacra, 14 mujeres (60,9%) y 9 hombres (39,1%), promedio de la edad 43 años (DE ± 12; rango 25-62). Casi todos eran pasajeros (n = 22; 95,7%) que viajaban sentados en la última fila del autobús (n = 20; 86,5%). Un solo caso correspondía aun conductor del vehículo. Se documentaron 29 lesiones vertebrales, 28 fracturas toracolumbares (de T10 a L2; 96,6%) y una fractura de coxis (3,4%). La vértebra más comprometida fue L1 (n = 16; 55%). Las fracturas más graves (A3/A4) se asociaron con tratamiento quirúrgico (p = 0,007) y una mayor mediana de días de internación (p = 0,005). **Conclusiones:** Las lesiones vertebrales asociadas al impacto vehicular con reductores de velocidad son fracturas causadas por un mecanismo de compresión axial, más frecuentes en pasajeros ubicados en la última fila de asientos del autobús. Comprometen predominantemente la charnela toracolumbar y la vértebra fracturada con más frecuencia es L1 y exclusivamente uno de los platillos vertebrales.

Palabras clave: Fractura vertebral toracolumbar; autobús; reductores de velocidad; lomo de burro; trauma.
Nivel de Evidencia: IV

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INTRODUCTION

Spinal fractures resulting from high-energy trauma are a widely developed topic in the literature, and traffic accidents are the leading cause of traumatic spinal injury, accounting for 38% of cases.[1] However, a subgroup of indirect traumatic spinal injuries occurring in bus passengers has been briefly described, which has prompted the development of our study. They comprise spinal injuries sustained when a vehicle passes abruptly over a speed bump (in Argentina, *lomo de burro*),which primarily affect bus passengers in the last row of seats.[2-4]

Speed bumps are elements used on streets as road safety measures to reduce the speed of traffic in certain urban areas. In Argentina, there is no exact record of when they began to be implemented, but in the 1990s, they became increasingly important as an instrument to control speed in residential areas, schools or intersections with high traffic without traffic lights, in order to avoid accidents. It should be noted that, under National Traffic Act No. 24,449, there is no precise definition that contemplates the use of speed bumps, so their construction and placement are not regulated, and therefore the types of design and signage differ.[5]

The aim of this study is to describe a series of cases of spinal fractures in bus passengers caused by speed bumps.

MATERIALS AND METHODS

We conducted a descriptive and retrospective study of a series of cases of thoracic and lumbosacral spine injuries sustained by bus passengers during vehicular impact with speed bumps, treated in two institutions of the Autonomous City of Buenos Aires' occupational and private systems between January 2012 and January 2023.

We included patients with spinal injuries affecting the thoracic, lumbar and sacrococcygeal spine, who had traumatic antecedents reported as "indirect trauma while driving or riding a bus due to vehicular impact with speed bumps". Cervical injuries were not included, in line with previous publications that have described this mechanism for thoracolumbar fractures specifically.[4] We excluded patients with oncological disease, severe or established osteoporosis documented in the clinical records (according to the World Health Organization classification that defines severe osteoporosis when a fragility fracture has already occurred), or impact against third parties or other objects that may bias the relationship with the typically described mechanism of injury.[4,6]

Data were collected from medical records and the image archive of radiographs, computed tomography and spinal magnetic resonance imaging on admission. The following variables were considered: age, sex, role in the vehicle (driver or passenger), place in the vehicle (last row of seats/driver/other), fracture classification according to the AO Spine classification system for thoracolumbar vertebral injuries,[7] neurological status on admission according to the *American Spinal Injury Association Impairment Scale*,[8] level and topography of the injury (thoracic: T1 to T9; thoracolumbar junction: T10 to L2; low lumbar: L3 to sacrococcygeal spine); previous comorbidities, treatment (conservative, surgical), complications, days of hospitalization, and days off work.

Vertebral compression fractures were grouped according to the severity of the vertebral body injury according to the AO classification morphology ("A0, A1 and A2" types vs. "A3/A4") for comparison.

All images were evaluated by two of the authors, the two most experienced spine surgery specialists on the team, for independent classification of the lesions. Disagreements were resolved by consensus among the research authors.

Statistical Analysis

Categorical variables are described as number and percentage. Numerical variables are expressed as mean and median according to their distribution (parametric or nonparametric) and their respective measures of dispersion, standard deviation and range. For comparison of categorical variables, the $\chi 2$ test or Fisher's test was used. Numerical variables were compared with Student's t test for independent samples or the Mann-Whitney U test, according to their distribution. A p-value <0.05 was considered statistically significant. SPSS v25 statistical software was used.

RESULTS

Table 1 shows the characteristics of the sample. Initially, 25 patients with vertebral fractures sustained during a bus trip were included. Two patients were excluded because the mechanism of injury was different from that typically described: one by direct trauma caused by another passenger and one by severe traumatic brain injury in the context of syncope. Finally, a sample of 23 patients with thoracolumbosacral spine injuries was obtained. Fourteen (60.9%) were female and nine (39.1%) were male, with a mean age of 43 years (SD ± 12; range 25-62). 82% were under 55 years of age. Almost all were passengers (n = 22; 95.7%) who were seated in the last row of the bus (n = 20; 86.5%). Only one subject was the driver of the vehicle. There were 29 vertebral injuries, 28 thoracolumbar fractures (from T10 to L2; 96.6%) and one coccyx fracture (3.4%). The most frequently involved vertebra was L1 (n = 16; 55%), followed by T12 (n = 6; 20.6%), T11 (n = 3; 10.4%) and L2 (n = 3; 10.4%). According to the AO Spine classification,[6] type A1 fractures (exclusive involvement of a single vertebral endplate, without involvement of the posterior wall) were the most frequent (n = 11; 50%), followed by type A3 (involvement of a single vertebral endplate and the posterior wall; n = 8; 36.4%). No injuries involving the anterior or posterior ligamentous complex, or signs of translation, were documented (Figures 1 and 2).

Table 1. Sample description (n = 23)

Variables		Results	
Age; mean (SD; range)		43	(±12; 25-62)
Sex, n (%)	Female	14	(60.9)
	Male	9	(39.1)
Role in the vehicle; n (%)	Driver	1	(4.3)
	Passenger	22	(95.7)
Place in the vehicle; n (%)	Driver	1	(4.3)
	Last row of seats	20	(86.9)
	Not documented	2	(8.7)
AO classification; n (%)	A1	11	(50.0)
	A2	2	(9.1)
	A3	8	(36.4)
	A4	1	(4.5)
Multiple fractures; n (%)		5	(22.7)
Neurological deficit; n (%)		1	(4.3)
Comorbidities; n (%)		6	(26.1)
Initial treatment; n (%)	Conservative	11	(47.8)
	Surgical	12	(52.2)
Complications; n (%)		5	(21.7)
Sick leave (days); median (range)		157	(55-518)
Length of hospital stay (days); median (range)		12	(1-31)

SD = standard deviation.

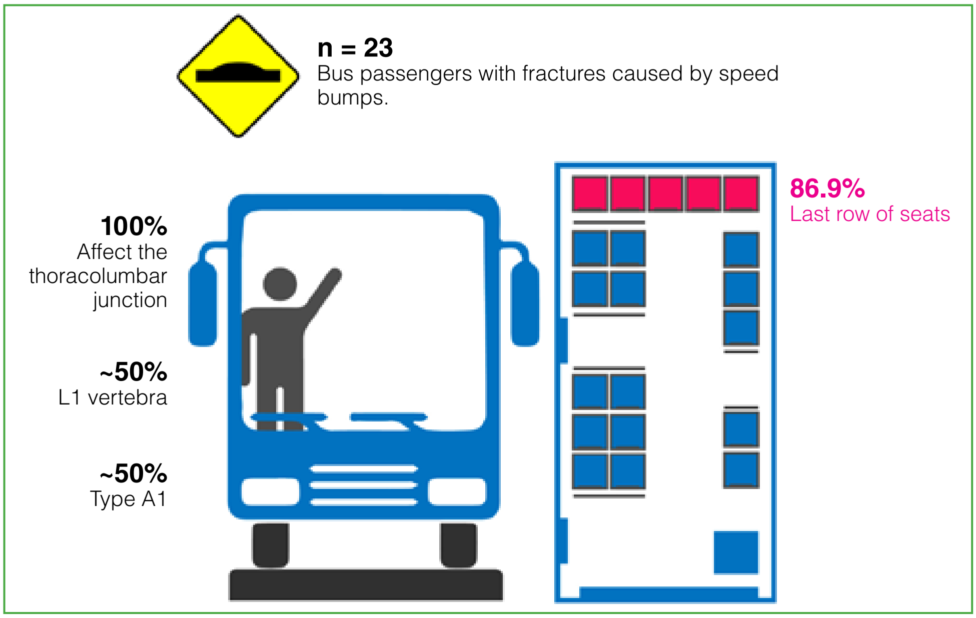

Figure 1. Infographic: summary of the main characteristics of the sample.

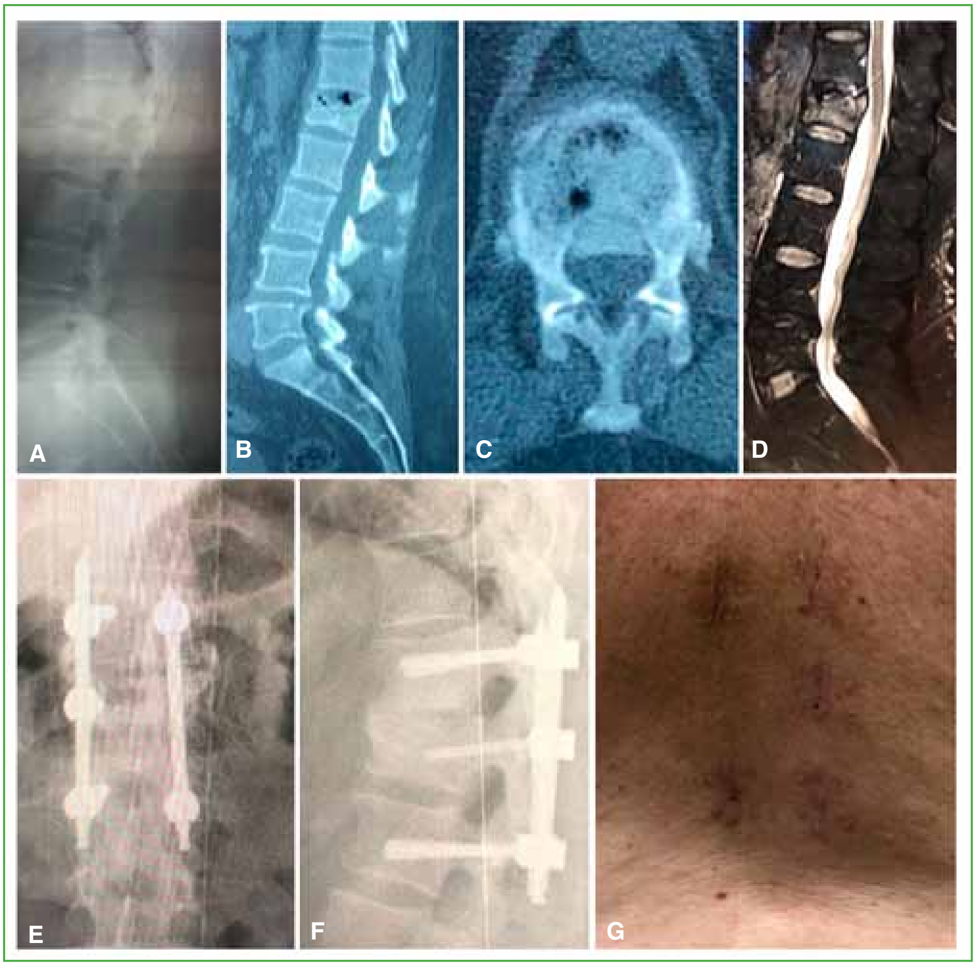

Figura 2. Case example: 51-year-old man with L1 fracture and involvement of the superior vertebral endplate and posterior wall, type A3 (**A-D**). Percutaneous short fixation (**E-G**).

Regarding initial treatment, 11 (47.8%) patients received conservative treatment: one with coccyx fracture (analgesia, rest and rehabilitation) and 10 with thoracolumbar fractures (A1 n = 8; A3 n = 1) who were immobilized with a Jewett brace. Three patients developed persistent and severe pain after eight weeks of treatment and underwent kyphoplasty as salvage treatment. 52.2% underwent initial surgical treatment. Surgical patients included: four with type A1 fracture treated with kyphoplasty (segmental kyphosis >20°, n = 2; brace intolerance, n = 1; decreased bone mineral density according to Hounsfield units on CT scan, n = 1); seven with type A3 fracture treated with short arthrodesis (n = 5), double-approach minimally-invasive arthrodesis (n = 1) or percutaneous fixation (n = 1) and finally, one with type A4 fracture and associated neurologic involvement treated with decompression and arthrodesis. The rate of complications in the sample was 21.7%: three cases of failure of conservative treatment (already mentioned) and two postoperative complications (one associated with the implant and the other, Guillain-Barré syndrome).

When comparing patients with thoracolumbar fractures according to injury severity (A1/A2 vs. A3/4), no statistically significant differences were found in the variables predictive of severity; however, posterior wall involvement had a statistically significant association with surgical indication (p = 0.007) and a higher median number of days of hospitalization (p = 0.005). Table 2 summarizes the results of the comparison.

Table 2. Comparison according to severity

Variables		Results				
		A1/A2 (n = 13)		A3/A4 (n = 9)		p
Age; mean (SD; range)		45	13 (25-62)	41	(11; 25-54)	0.562
Sex; n (%)	Female	8	(61.5)	6	(66.7)	0.806
	Male	5	(38.5)	3	(33.3)	
Role in the vehicle; n (%)	Driver	1	(7.7)	0	(0)	0.394
	Passenger	12	(92.3)	9	(100)	
Place in the vehicle; n (%)	Driver	1	(8.3)	0	(0)	0.402
	Last row	11	(91.7)	8	(100)	
Multiple fractures; n (%)		4	(17.39)	1	(11.1)	0.279
Neurological deficit; n (%)		0	(0)	1	(11.1)	0.219
Comorbidities; n (%)		4	(30.8)	2	(22.2)	0.658
Initial treatment; n (%)	Conservative	9	(69.2)	1	(11.1)	0.007
	Surgical	4	(30.8)	8	(88.9)	
Complications; n (%)		3	(23.1)	2	(22.2)	0.962
Time off work (days); median (range)		134	(55-518)	207	(127-499)	0.62
Days of hospitalization; median (range)		6	(1-28)	18	(12-31)	0.005

SD = standard deviation.

DISCUSSION

Few studies have been published on speed bump fractures. Bowrey et al. are believed to have described the first two cases of spinal injuries caused by a vehicle passing over a "road hump" at high speed.[2] Nine years later, Aslan et al. reported five patients with such fractures, but, so far, without reference to the mechanism of injury.[3] Subsequently, Munjin et al. published the largest series of patients to date, with 46 cases and 52 spinal fractures secondary to trauma caused by a vehicle passing over speed bumps.[4] They also described in detail the characteristics of the injury mechanism, proposing that when the vehicle rises as it passes over the speed bump, an upward vertical force is generated, which is determined by the speed at which the vehicle impacts the speed bump and the distance between its point of application and the center of support. Then, as the vehicle speed increases, a catapult-like effect on the vehicle suspension system is exacerbated. As a consequence, the passenger or driver rises suddenly from his seat and then falls abruptly due to the force of gravity, generating an axial compression mechanism on the spine.[4]

The demographic characteristics of our series were similar to those of the published series, with a predominance of female sex (60%) and a mean age of 43 years.[2-4]

In our series, the majority of patients were passengers seated in the back row, which is similar with the three previously published series in which more than 90% had this context.[2-4] Munjin et al. suggested that the position of the back row of seats represents the farthest distance to the rear wheel of the bus and the location of the bus with the least amount of damping. The upward inertial force generated at this level is of greater amplitude and length. In turn, the posterior axial compression force created by the passengers' sudden descent is greater due to the distance traveled and the lack of a closer support point in relation to the damping system. This is why passengers in the rear row of seats absorb the greatest force of impact and are at the highest risk of sustaining traumatic spinal injuries.[4]

Our data on the most frequent location, vertebra and type of fracture were similar to those published.[4] The thoracolumbar junction was the most frequently involved spinal region (96.6%; n = 28) and the L1 vertebra (55%; n = 16) was the most frequently fractured. The energy of the impact is absorbed, to a greater extent, by the group of vertebrae that are in the transition zone between the rigid dorsal spine and the mobile lumbar spine. The most frequent type of fracture according to the AO Spine classification was A1 (50%, n = 11).[7]

There were no cases of injuries to the anterior or posterior ligament complex (type B and C fractures) as in the published series, in line with the predominant axial compression mechanism proposed in the literature.[2-4]

The overall complication rate was 21.7% (n = 5). It should be noted that strictly surgical complications were low: only one patient presented implant failure. Surprisingly, one patient developed Guillain-Barré syndrome 14 days after surgery, an extremely rare association but documented in the literature, which resolved completely.[9,10] In three patients, conservative treatment failed due to brace intolerance, prompting rescue treatment with kyphoplasty.

It should be noted that most of the patients were treated in the context of an occupational accident on their way to or from work. During the initial evaluation of patients with occupational accidents, it is often necessary to diagnose a pre-existing condition, unrelated to the accident, which may interfere with the pathogenesis of the injury. Bone fragility, for example, makes the patient more likely to sustain a fracture with low energy trauma. We believe it is relevant to highlight that most of the patients in the sample (n = 19; 82%) were young adults, <55 years old, and that patients with documented severe osteoporosis or pathological fracture causes were excluded. In the authors' opinion, this reflects the severity of the kinetics of trauma in the context of vehicular impact against speed bumps, and configures the injury as a traumatic vertebral fracture. In addition, in nine patients, the kinetics of the accident resulted in severe vertebral injuries, with posterior wall involvement and evident or potential mechanical instability. More severe vertebral fractures, with posterior wall involvement, were associated with a higher indication for surgery and longer hospitalization times. In agreement with our results, Munjin et al. published a series of 10 patients with severe injuries and indication for surgery. On the other hand, they also highlighted the positive history of bone metabolism disorders in 23%, and suggested that patients with osteoporosis should avoid the last row of seats in the bus.[4]

The main weaknesses of our study are its descriptive and retrospective design, the low number of patients that prevents generalizing its conclusions, and the probable selection, measurement and recording biases. Some patients were most likely excluded because their injury mechanism was not documented in the clinical record. However, given the small number of published cases, with only one series reported in indexed journals according to our literature search, we believe our work contributes to promoting a better clinical interpretation of a known cause of injury that has received little attention in the literature.

CONCLUSIONS

Spinal injuries caused by vehicular impact against speed bumps are fractures generated by an axial compression mechanism, and they occur more frequently in passengers seated in the last row of the bus. They primarily affect the thoracolumbar junction, with the most often fractured vertebra being L1 and only one of the vertebral endplates involved. They could potentially cause more serious injuries to the posterior wall or generate evident or potential mechanical instability. Our study suggests that spine fractures caused by vehicular impact with speed bumps (or 'sleeping policemen') should be classified as traumatic spinal injuries due to the high prevalence of young adult patients (<55 years) without bone metabolism conditions.

Conflict of interest: The authors declare no conflicts of interest.

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