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Thoracolumbar Fractures Due to Speed-humps: A Case Series of Spine Fractures from an Atypical Cause of Injury

Fraturas toracolombares por lombadas: Uma série de casos de fraturas da coluna vertebral por uma causa atípica de trauma

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Abstract

This retrospective case series investigates thoracolumbar fractures resulting from speed humps during bus travel in Rio de Janeiro. The study encompasses 19 patients who experienced such fractures between 2013 and 2021 without collision events. Factors examined included demographics, injury specifics, management strategies, and outcomes. The study aims to elucidate the prevalence, characteristics, and treatment of these injuries. Analyses were conducted using clinical evaluations, AOSpine classification, Visual Analog Scale (VAS) for pain, and TL AOSpine Injury Score (TL AOSIS). Surgical and non-surgical interventions were compared, highlighting the need for strict traffic regulations and preventive measures to mitigate such accidents. Results reveal a predominance of fractures in women, with a mean age of 61.26 years, and an emphasis on L1 vertebra involvement. Surgical intervention was required in over 50% of cases, demonstrating favorable outcomes. However, limitations due to the study's retrospective nature and the tertiary care setting were acknowledged. The study concludes by emphasizing the importance of preventive measures, such as stricter traffic regulations, mandatory seatbelt use in public transportation, and enhanced speed-hump safety measures to curtail these accidents and subsequent injuries.

Keywords

- thoracolumbar fractures
- spinal cord injuries
- speed-hump
- low back pain

Resumo

Esta série de casos retrospectiva investiga fraturas toracolombares resultantes de lombadas durante viagens de ônibus no Rio de Janeiro. O estudo abrange 19 pacientes que sofreram tais fraturas entre 2013 e 2021 sem eventos de colisão. Os fatores

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examinados incluíram dados demográficos especificidades da lesão estratégias de tratamento e resultados. O estudo visa elucidar a prevalência características e tratamento dessas lesões. As análises foram conduzidas usando avaliações clínicas classificação AOSpine Escala Visual Analógica (VAS) para dor e TL AOSpine Injury Score (TL AOSIS). Intervenções cirúrgicas e não cirúrgicas foram comparadas destacando a necessidade de regulamentações de trânsito rigorosas e medidas preventivas para mitigar tais acidentes. Os resultados revelam uma predominância de fraturas em mulheres com idade média de 61 26 anos e ênfase no envolvimento da vértebra L1. A intervenção cirúrgica foi necessária em mais de 50% dos casos demonstrando resultados favoráveis. No entanto limitações devido à natureza retrospectiva do estudo e ao cenário de cuidados terciários foram reconhecidas. O estudo conclui enfatizando a importância de medidas preventivas como regulamentações de trânsito mais rigorosas uso obrigatório de cinto de segurança no transporte público e medidas de segurança aprimoradas em lombadas para reduzir esses acidentes e ferimentos subsequentes.

Palavras-chave
- fraturas toracolombares
- lesões da medula espinhal
- lombada
- dor lombar

Introduction

Speed humps are devices placed in the path of traveling vehicles intended to cut down the relatively high rate of in-city motor vehicle accidents. Their main benefit lies in reducing vehicle speed, and thus improving traffic safety for residents and pedestrians in the neighboring area. They are placed predominantly on minor roads, which are both crowded by pedestrians and where vehicles are likely fast cruising. Unfortunately, speed humps are not always built according to regulations and vary from the original designs and can unintentionally cause spinal column injuries.[1–3]

Thoracolumbar traumatic injury ranges from 12 to 50 million patients annually in the United States and fractures in this area account for approximately three-quarters of all spinal fractures.[4,5] The T10-L2 junction is a biomechanical area of susceptibility to fractures due to the transition between the relatively stiff thoracic spine and the flexible lumbar spine. This area corresponds to 50–60% of the thoracolumbar spine injuries.[5,6]

The most common type of fracture that needs surgical intervention is the burst fracture, which is also the most severe of the compression fractures, as it can cause retropulsion of endplate fragments into the spinal canal leading to neurological deficit.[4,5,7] Mechanisms of injury include high-velocity pattern of axial compression as the most common, such as falls from height, motor vehicle crashes, pilot ejection, parachute jumping, vertical acceleration and sports impacts.[4,5,8]

The most common population of general thoracolumbar fractures is young adults and adolescents between 15–29 years.[5] Younger patients are more likely to have a high-energy spinal cord injury associated with other organ lesions, and elderly individuals are more susceptible to low-energy mechanisms such as low fall. However, both groups have their morbidity to be a burden to the society.[6]

The mechanism of these fractures was well described by Munjin et al.[3] A torque is generated when the vehicle rises while passing over the speed hump, and the magnitude of this force is determined by the speed at which the vehicle impacts the device and the distance between its application point and the axis of the wheel that remains in contact with the road. The torque then generates a catapult effect on the vehicle's suspension system and, as a result, the passenger elevates suddenly from his seat, falling back abruptly and hitting the seat shortly because of gravity, generating an axial force that is then absorbed by the spine, explaining the fact that all of the patients in this series presented compression fractures.

The lap-shoulder belt in association with airbags reduced the incidence rate of these injuries,[6] however the extent of these protection gadgets does not go further as they are not well established for public transportation.[3]

There are only three studies that report a case series of this type of injury,[1–3] since it's a recognized cause of spine fracture and chronic low back pain. We now present a series of cases of thoracolumbar fractures caused by vertical dislocation in patients on bus seats in the city of Rio de Janeiro.

Methods

This study is a single-center, retrospective, consecutive case series review performed at the Division of Neurosurgery of Gaffrée and Guinle University Hospital (HUGG), Federal University of the State of Rio de Janeiro. HUGG's Research Ethics Committee approved the study and dismissed the application of the Free and Informed Consent Term, as the study consists of a retrospective review of data collected from previously operated patients' charts. Preferred Reporting of Case Series in Surgery (PROCESS) guidelines were followed.[9]

Our sample is composed of 19 patients who suffered thoracolumbar fractures during bus travels in the period between 2013 and 2021, without any collision event. We registered age, sex, comorbidities, date of injury, type of treatment, presence of radicular pain, ASIA score before and after treatment,[10] AOSpine thoracolumbar spine injury classification,[11] levels of injury, Thoracolumbar AOSpine Injury Score (TL AOSIS)[12] and Visual Analog Scale (VAS) score[13] of all the patients and evaluated them 2 weeks, 3 months,

6 months, 12 months, and 24 months after the surgery or the first use of the Putti vest. Each patient management was based on the findings of each case: stable fractures were treated with analgesics, orthoses (Putti vest), and mild rest for 3 months; unstable fractures (AO spine fracture types A3 and A4) received surgical intervention with spinal decompression and arthrodesis; and patients with important refractory pain after 3 months of conservative treatment received kyphoplasty.

Statistical analyses were performed using the Python programming language (Python Software Foundation, Delaware, USA). Outcome variables were assessed before and after the intervention, using the Wilcoxon test or paired *t*-test as appropriate. The rank biserial correlation (RBC) was calculated for each relationship, with values from 0.2 to 0.5 considered a mild association, 0.5 to 0.8 a moderate association, and above 0.8 a strong association. A p-value < 0.05 was used as statistically significant and a 95% confidence interval and standard deviation were calculated when appropriate.

Results

The results obtained are summarized in ►**Table 1**. All our patients were evaluated using clinical and imaging exams, in which none presented any kind of myelopathy, any motor deficit, M1 modifier on the AOSpine classification, or a TL AOSIS greater than 5. None of the patients were bus drivers and all of them were sitting on the bus bench during the accident, without the use of seat belts. All patients reported that their lumbar pain began after the bus drove by a speedbump at high speed.

Among the sample, 17 (89.47%) patients were women, and the ages ranged from 33 to 82 years (mean age of 61.26 years $\pm$ 11.2). Of all the patients, only two (10.52%) had a second thoracolumbar fracture on another date by the same cause, and of those one (5.26%) had conservative management on the first trauma and surgical management on the second, and the other needed surgery on both events. Concerning the management choice, ten (52.63%) individuals

Fig. 2 Patient 19: CT scan showing the intravertebral cement in the T12 vertebra.

Fig. 3 Patient 13: T2-weighted MRI showing an A1 fracture of the L1 vertebra (white arrow).

Fig. 1 Patient 2: intraoperative picture of T10-L3 transpedicular arthrodesis.

Fig. 4 Patient 14: T2-weighted MRI showing an A4 fracture of the L3 vertebra.

Table 1 Patient Demographics and Trauma Characteristics

Name	Age	Sex	Date of Trauma	Comor-bidities	Type of Treatment	Type of Surgery	AOSpine thoracolumbar spine injury classification	TL AOSIS	Fracture Level	Radiculo-pathy	AVS before treatment	AVS after 2 weeks of surgery	AVS after 3 months of intervention	AVS after 6 months of intervention	AVS after 12 months of intervention	AVS after 24 months of intervention
Patient 1	67	F	2017	HBP and Osteopenia	Surgical	Kyphoplasty	A2N0M2	2	T11	No	10	1	3	3	3	1
Patient 1	67	F	2019	HBP and Osteopenia	Conservative	–	A1N0M2	1	T12	No	8	–	5	2	2	1
Patient 2	58	F	2018	–	Surgical	T10-L3 Arthrodesis	A3N0	3	L1	No	10	2	2	3	3	3
Patient 3	66	F	2013	HBP	Surgical	Kyphoplasty	A1N0M2	1	T11	No	10	3	1	1	1	1
Patient 3	66	F	2016	HBP	Surgical	T10-L2 Arthrodesis	A4N0M2	5	L1	No	10	3	1	1	1	1
Patient 4	82	F	2017	Osteopenia	Conservative	–	A2N0M2	2	L2	No	9	–	5	2	0	0
Patient 5	64	M	2017	–	Surgical	Kyphoplasty	A1N0	1	L2	No	10	4	3	2	2	1
Patient 6	62	F	2017	–	Surgical	L3-L5 Arthrodesis	A1N2	3	L4	Left (L4)	8	4	3	4	4	3
Patient 7	69	F	2015	HBP	Conservative	–	A2N0M2	2	L3	No	9	–	4	4	4	2
Patient 8	71	F	2013	DM	Surgical	Kyphoplasty	A1N0M2	1	L2	No	8	3	2	2	2	1
Patient 9	57	F	2018	–	Conservative	–	A2N0	2	T11	No	10	–	5	1	1	1
Patient 10	56	F	2019	–	Conservative	–	A2N0	2	T12	No	10	–	6	2	2	1
Patient 11	64	F	2020	–	Conservative	–	A1N0	1	L2	No	7	–	3	0	0	0
Patient 12	68	F	2019	–	Conservative	–	A2N0	2	L1	No	8	–	4	1	1	0
Patient 13	60	F	2020	–	Conservative	–	A1N0	1	L1	No	5	–	3	3	3	2
Patient 14	33	F	2014	–	Surgical	L2-L4 Arthrodesis	A4N2	5	L3	Right (L3)	9	3	1	1	1	1
Patient 15	36	F	2016	–	Conservative	–	A2N0	2	T11	No	8	–	4	0	0	0
Patient 16	74	M	2018	HBP	Surgical	T11-L3 Arthrodesis	A3N0	3	L1	No	9	4	4	2	2	2
Patient 17	59	F	2020	DM	Conservative	–	A2N0M2	4	T10	No	8	–	4	1	0	0
Patient 18	57	F	2020	HBP	Surgical	T11-L3 Arthrodesis	A1N0M2	1	L1	No	10	2	1	0	0	0
Patient 19	61	F	2021	–	Surgical	Kyphoplasty	A2N0	2	T12	No	7	3	2	1	1	1

needed surgical treatment which varied between arthrodesis ($n = 6$, 31.58% - ►**Figure 1**) and kyphoplasty ($n = 5$, 29.41% - ►**Figure 2**).

The 2 most frequent AOSpine thoracolumbar spine injuries of all the 21 fractures evaluated were the split/AO type A2 ($n = 9$, 42.86%) and wedge compression/AO type A1 ($n = 8$, 38.1%) fractures (►**Figure 3**), followed by incomplete burst/AO type A3 ($n = 3$, 14.29%) and burst/AO type A4 ($n = 1$, 4.76% - ►**Figure 4**), and concerning the level of the fractures we found that the most injured vertebra was the L1 ($n = 6$, 28.57%), followed by T11 ($n = 4$, 19.05%), L2 ($n = 4$, 19.05%), T12 ($n = 2$, 9.52%) and L3 ($n = 2$, 9.52%), T10 ($n = 2$, 9.52%) and finally L4 ($n = 1$, 5.26%). Of the two (10.53%) patients that had two subsequent fractures, one had formerly an A2 and later A1 fractures of the T11 and T12 vertebrae, respectively, and the other one had an A1 fracture at first and an A4 injury on the second event of the vertebrae T11 and L1, also respectively.

To better understand the pain manifestations of each patient, we evaluated the presence of radiculopathy and the affected root and used VAS to measure pain. Only 2 (10.53%) patients had radiculopathy after the trauma (AOSpine N2), which improved right after the surgical procedure. Since two of our patients had two fractures on different occasions, we evaluated twice their VAS, so considering 21 VAS evaluations, we had a mean score of 8.71 ± 1.31 before intervention, 2.91 ± 0.9 after 2 weeks of surgical procedure (in those operated - $n = 11$), 3.14 ± 1.46 after 3 months of intervention, 1.71 ± 1.16 after 6 months of intervention, 1.57 ± 1.26 after 12 months of intervention and 1.05 ± 0.89 after 24 months of intervention.

None of the patients had an additional injury to the tension band (modifier M1) and eight patients (42.11%) had an M2 modifier (presence of co-morbid condition). Using the TL AOSIS, we found that considering 21 fractures, we had a mean score of 46 ± 1.22, in which 3 patients (14.29%) had a score between 4 and 5, and 85.71% had a score lower than 4 points.

Discussion

In Brazil, all speed bump implementation needs to be approved by the National Transit Council (Conselho Nacional de Trânsito - CONTRAN). Since 1998 all speed bumps have been forbidden by law and built only in specific situations and with the authorization of CONTRAN following a list of specifications so that the device can be safely used in traffic.[13] Unfortunately, they are not always built according to regulations, and vary from the original designs, and can unintentionally cause accidents, including spine injuries. Another problem that Brazilian traffic faces is that the installation of seat belts is not obligatory in vehicles that allow passengers to ride standing, like most of the public buses in Brazil.[14]

The most common population of general thoracolumbar fractures is young adults and adolescents between 15–29 years.[5] However, when we look at the other studies regarding specifically speed bump fractures,[1–3] Mujin et al.[3] found a mean age of 48.5 years and in our series, we observed that our mean age was 61.26 and the youngest patient was 33 years. The literature usually finds a slightly greater incidence in men,[5,6,16] although when speed humps injuries are investigated, Munjin et al.[3] and our study found a greater incidence in women, 80.4% and 88.2% respectively. We believe that this divergence from the general causes is due to the risk factors involved, that increase the incidence of fractures in this setting since most of the patients are postmenopausal women, a group that has a greater predisposition to fractures from low energy traumas.[17]

It is important to note that none of our patients was the bus driver and that all of them were sitting on a bus. Workers who stay too long seated and are subjected to vibrations from a vehicle ride have an increased risk factor for cervical and lumbar pain and spine degeneration. It is estimated that 80.5% of bus drivers experience some kind of back or neck pain, without any assistance or type of rehabilitation, unfortunately, there has never been a study to quantify and investigate degenerative spine diseases in this group of patients.[18,19] Following Mujin et al. line of work, we can theorize that bus drivers don't usually have this kind of fractures because they are seated on the place with the least torque inside a bus during the accident.[3]

Regarding the most vulnerable vertebra, L1 is found to be the most fractured in thoracolumbar traumas in both high and low-energy situations. Katsuura et al, Li et al and Munjin et al found, respectively, 34.4%, 35.6%, and 44.2% cases of L1 fracture in their studies, being the most common site of fracture.[3,6,7] This was also the most common fracture in our series, representing 28.57% of our cases. Regarding the type of AOSpine fracture, our study observed that a split/AO type A2 fracture was the most common (42.86%) but not significantly different from the wedge compression/ AO spine type A1 fractures (38.1%), Munjin et al found that the A1 fracture was the most common in their study, with an incidence of 57.7%.[3] Comparatively, Katsuura et al found that the incomplete burst/AO type A3 fractures were the most common morphology 39.50%.[7] We believe that since our work and the one from Munjin et al study low-energy fractures, we would find injuries that needed more conservative management, and since Katsuura et al evaluate other types of injuries, they would find more severe fractures that needed surgical treatment.[3,7] It is also worth pointing out that despite 4 of our patients having more than 50% of their vertebral body collapsed, only two patients had sensitive manifestations, represented as radiculopathy.

The management of thoracolumbar injury is controversial but some cases require surgical approaches, which happened in 52.63% of our sample.[3,5,16,20] We treated them following some criteria: A3 or A4 fractures were submitted to spinal decompression and transpedicular arthrodesis (4 levels in 3 patients and 2 levels in the rest), accordingly to each patient and fracture level, and following the load-sharing classification[21,22]; and patients with A1 or A2 fractures with important refractory pain after 6 months of conservative treatment received kyphoplasty. Only one patient treated surgically needed a new approach, she received a kyphoplasty initially, and after 3 years she had a new fracture and was submitted to posterior arthrodesis. Munjin et al. study observed that 21.7%

of their patients were submitted to surgery, including patients with A2 fractures who were surgically treated to avoid the risk of pseudoarthrosis, as a result of disc herniation into the vertebral body, unfortunately, it is not known if any patient treated initially conservatively needed surgery in the follow-up.[3] We compared our patients' management with the proposed by the TL AOSIS and observed that our study agreed with the suggestions based on the patient's score.

At the first evaluation, we had a mean score of 8.71 regarding all patients, and after 3 months we found a score of 2.91 in the group submitted to surgery ($n = 11$) and 4.3 in the conservative group ($n = 10$). After 12 months, we observed a mean VAS score of 1.82 in the surgical group ($n = 11$) and 1.3 in the conservative one ($n = 10$). When compared, the intervention group had a faster and greater recovery compared with the conservative group, demonstrated by the effect size of 0.56 (moderate association) when comparing these data, which may cause the early return to work and impact better recoveries with increased life quality.[3] As far as we know, this is the first study that quantifies pain and uses the AVS to evaluate it.

Our study is not free of limitations, since our study is inherently limited by its small sample and its retrospective nature, burdening the formulation of hypotheses and associations between variables. Another problem we faced is that our hospital is a tertiary care facility without an emergency room, and all patients are referred from other specialties or hospitals, a fact that can explain the number of patients we treated with this condition since we believe there are even more individuals with thoracolumbar fractures in Rio during public transport.

Conclusion

Regarding the pain, the results in surgical and non-surgical cases were satisfying. We could also better understand an important cause of thoracolumbar fractures in which ~50% of patients will need neurosurgery. However, the most important "treatment" is the prevention of these accidents with quality work of the government with safer and stricter traffic rules, including the obligation of seatbelt use in public transportation, better signaling for the decrease of speed limit violations, and the inspection of speed-humps.

Conflict of Interest
None.

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