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Editor
Nancy E. Epstein, MD
Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook

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Original Article

Spinal canal invasion as a predictor of neurological deficit in traumatic vertebral burst fractures

Oscar Josue Montes-Aguilar[1], Karmen Karina Alaniz-Sida[2], Manuel Dufoo-Olvera[1], Guillermo Ivan Ladewig-Bernaldez[1], Edith Oropeza-Oropeza[1], Gerson Gómez-Flores[1], Jeasson Javier Pérez-Rios[1], Alejandro Miguel-Zambrano[1], Maurilio Vicente Ochoa-González[3], Héctor Alonso Tirado-Ornelas[3]

[1]Mexico City Spine Clinic, "Dr. Manuel Dufoo Olvera", Mexico City, Departments of [2]Neuroanestesiology, and [3]Neurosurgery, Specialties Hospital, La Raza National Medical Center, Mexican Social Security Institute, Mexico City, Mexico.

E-mail: *Oscar Josue Montes-Aguilar - oscar_16031@hotmail.com; Karmen Karina Alaniz-Sida - karialanizs@gmail.com; Manuel Dufoo-Olvera - Mdufoo27@yahoo.com; Guillermo Ivan Ladewig-Bernaldez - dr.ladewig@gmail.com; Edith Oropeza-Oropeza - dra.edith.oropeza@gmail.com; Gerson Gómez-Flores - drgersongomez@gmail.com; Jeasson Javier Pérez-Rios - jeasson62@gmail.com; Alejandro Miguel-Zambrano - alexmizam@gmail.com; Maurilio Vicente Ochoa-González - maurilio.ochoag@gmail.com; Héctor Alonso Tirado-Ornelas - hector.alonso.7@hotmail.com

***Corresponding author:**
Oscar Josue Montes-Aguilar,
Mexico City Spine Clinic
"Dr. Manuel Dufoo Olvera",
Mexico City, Mexico.

oscar_16031@hotmail.com

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ABSTRACT

Background: This study correlated the extent of spinal canal compression from retropulsed traumatic burst cervical, thoracic, and lumbar spine fractures with the severity of neurological dysfunction.

Methods: One hundred and sixty-nine patients with cervical, thoracic, or lumbar sub-axial traumatic burst fractures were seen in an emergency department from 2019 to 2021; 79.3% were men, averaging 37 years of age. The lumbar spine was most frequently involved (42%), followed by the thoracic (36.1%) and cervical (21.9%) levels. The extent of spinal canal compression was quantitated utilizing Hashimoto's method, and correlated with patients' extent of neurological injury based on their American Spinal Injury Association scores.

Results: There was a positive correlation between the extent of cervical and thoracic spinal cord compression due to retro pulsed burst fragments and the severity of the patients' neurological deficits, but this was not true for the lumbar spine.

Conclusion: The extent of spinal cord compression from retropulsed cervical and thoracic traumatic burst fractures was readily correlated with the severity of patients' neurological dysfunction. However, there was no such correlation between the extent of cauda equina compression from retropulsed lumbar burst fractures and the severity of their cauda equina syndromes.

Keywords: Burst fractures, Canal invasion, Spine trauma, Spine, Subaxial fractures

INTRODUCTION

Different combination of plain X-rays, magnetic resonance, and computed tomography (CT) studies are used to assess the extent of spinal canal compromise and neurological deficits due to retropulsed cervical, thoracic, and lumbar burst fractures.[2,7,10] Here, we correlated the extent of spinal canal and neurological compromise attributed to cervical, thoracic, and/or lumbar such retropulsed traumatic burst fractures.[1,4]

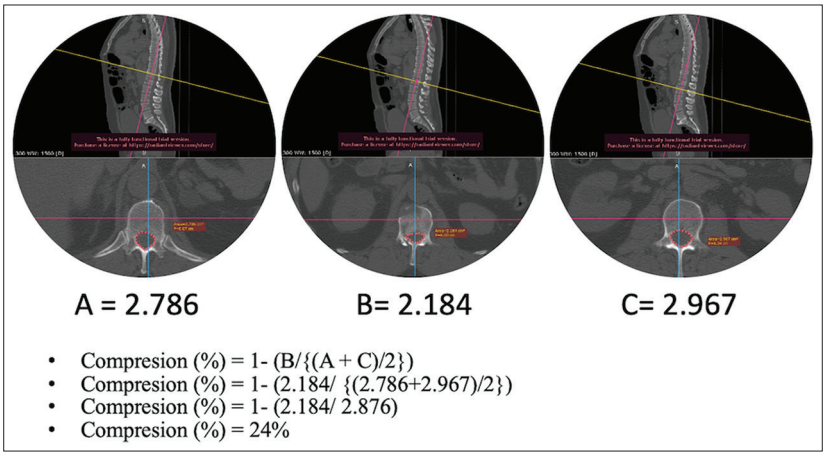

Figure 1: Spinal cord compression in a computed tomography using the Hashimoto method: transversal area of the spinal canal of the fractured vertebra, and the mean transversal area of the spinal canal from the adjacent vertebra (superior and inferior).

MATERIALS AND METHODS

Clinical series

CT-Documented inclusion criteria

To be included in this study, patients' CT studies had to demonstrate traumatic burst spine fractures (2019–2021) involving the sub-axial cervical (C3–7) spine, the thoracic spine, and/or the lumbar spine. The frequency of such burst fractures in descending order involved the lumbar (42%), followed by the thoracic (36.1%) and cervical (21.9%) regions. The extent of spinal canal compression (i.e., 50% had stenosis of greater than 47%) was measured on CT studies using Hashimoto's method (i.e., transversa area of the spinal canal at the fracture level divided by mean transverse area of the spinal canal from the adjacent superior and inferior vertebrae[6] [Figure 1].

Clinical review

We reviewed the complete electronic medical records and obtained written informed consent from 169 patients 79.3% of whom were male, averaging 37 years of age. All had vertebral burst fractures with most demonstrating incomplete spinal cord injuries [Table 1].

Neurological deficits based on American spinal injury association (ASIA) scores

Neurological deficits were assessed using the ASIA score.[11]

The authors performed a linear regression stratification of the different spinal level burst fractures to determine the correlate of the CT-documented extent of canal compromise with their resultant neurological deficits (i.e., using ASIA score and the Mann–Whitney test) [Table 2].

Table 1: Baseline characteristics.

	***n* (%)**
Age*	37 (26–49)
Sex	
Man	134 (79.3)
Woman	35 (20.7)
Segment	
Cervical	37 (21.9)
3	(5.4)
4	(21.6)
5	(32.4)
6	(32.4)
7	(8.1)
Thoracic	61 (36.1)
7	(9.8)
8	(13.1)
10	(14.8)
11	(13.1)
12	(23)
Lumbar	71 (42.0)
1	(46.5)
2	(26.8)
3	(15.5)
4	(10)
5	(1.4)
Spinal canal invassion* (%)	0.47 (0.27–0.66)
0–24	23 (13.7)
25–49	37 (22.0)
50–74	24 (14.3)
75–100	84 (50.0)
Neurological deficit (ASIA)	
A	41 (26.1)
B	16 (10.2)
C	17 (10.8)
D	67 (42.7)
E	16 (10.2)

*Median (IQR), ASIA: American spinal injury association

Table 2: Association of spinal cord compression and neurological deficit stratified by regions.

	Neurological deficit					
Region	**ASIA A**	**ASIA B**	**ASIA C**	**ASIA D**	**ASIA E**	***P*-value**
Proportion of compression						
Total	0.53 (0.39–0.78)	0.60 (0.41–0.67)	0.49 (0.39–0.64)	0.32 (0.22–0.49)	0.67 (0.34–0.82)	0.004
Cervical	0.98 (0.91–1.00)	0.64 (0.58–0.67)	0.39 (0.33–0.54)	0.28 (0.22–0.36)	0.00 (0.00–0.00)	0.001
Thoracic	0.45 (0.36–0.55)	0.22 (0.22–0.22)	0.12 (0.12–0.12)	0.14 (0.11–0.21)	0.02 (0.02–0.02)	0.003
Lumbar	0.54 (0.54–0.54)	0.55 (0.45–0.73)	0.56 (0.47–0.64)	0.44 (0.28–0.64)	0.71 (0.44–0.86)	0.146

Median (IQR) ^Kruskal–Wallis

Table 3: Association of spinal cord compression and neurological deficit: Linear regression models.

		***P*-value**	**CI 95%**
All regions			
ASIA A	Ref.		
ASIA B	−0.037	0.674	−0.210, 0.136
ASIA C	−0.102	0.204	−0.260, 0.056
ASIA D	−0.210	0.000	−0.326, −0.095
ASIA E	0.010	0.908	−0.170, 0.190
Cervical region			
ASIA A	Ref.		
ASIA B	−0.370	0.000	−0.539, −0.201
ASIA C	−0.530	0.000	−0.728, −0.332
ASIA D	−0.652	0.000	−0.800, −0.505
Thoracic region			
ASIA A	Ref.		
ASIA B	−0.243	0.155	−0.585, 0.099
ASIA C	−0.343	0.049	−0.685, −0.001
ASIA D	−0.311	0.000	−0.458, −0.016
ASIA E	−0.443	0.013	−0.785, −0.101
Lumbar region			
ASIA A	Ref.		
ASIA B	0.045	0.850	−0.430, 0.520
ASIA C	0.001	0.996	−0.447, 0.449
ASIA D	−0.091	0.672	−0.523, 0.341
ASIA E	0.125	0.579	−0.326, 0.576

ASIA: American spinal injury association

RESULTS

Correlation of cervical and thoracic spinal canal compression from burst fractures with neurological deficits

The authors observed a positive correlation between the extent of cervical and thoracic spinal canal compression and the severity of patients' neurological deficits. In the cervical spine, the median compression was 0.98 for ASIA A, which proportionally decreased for less severe spinal injuries [Table 3]. A similar association was seen for those with thoracic spine lesions. However, there was no correlation between the extent of burst fractures involving the lumbar spinal canal and resultant cauda equina syndromes [Table 3].

DISCUSSION

We found the extent of cervical and thoracic canal compromise attributed to retropulsed vertebral burst fractures/fragments positively correlated with the severity of resultant neurological deficits, similar to the findings of Fontijne *et al*., who found a significant correlation between neurological deficit and the percentage of spinal canal stenosis, but the severity could not be predicted.[5] However, there was no such association with lumbar burst fractures and the severity of cauda equina syndromes (i.e., ASIA A median stenosis 54% vs. ASIA E median stenosis 71%). Other studies have reported similar findings of the latter lack of correlation in the lumbar spine like Keene *et al*. in 1989 who found a negative association between the immediate,

posttraumatic neurologic status and the percent of neural canal impingement, or more recent Mohanty *et al*. who found no association between the extent of canal compromise and the severity of neurological deficit at the thoracolumbar spine [Table 4].[8,9] This negative association has been explained by different theories including the different reserve capacity in the lumbar versus cervical/thoracic spine, the presence of the cauda equina nerve roots in the lumbar spine versus cervical/thoracic cord, and the energy/force resulting in different levels of spinal fractures.[3,11-14]

Table 4: Association of spinal cord compression and neurological deficit: Summary of the previous studies findings.

Year	Author	Title	# Pacients	Segments	Radiology	Association	Conclusion
1984	Trafton and Boyd	Computed tomography of thoracic and lumbar spine injuries	73	T, L	CT	Positive	Burst fractures at T12-L1 >50% decrease of the mid-sagittal neural canal diameter=Risk of neurologic involvement and progressive deficit[13]
1988	Hashimoto *et al*.	Relationship between traumatic spinal canal stenosis and neurologic deficits in thoracolumbar burst fractures	112	T, TL, L	CT	Positive	Established spinal canal stenosis ratios at epiconus, conus medullaris and cauda equina as risk factors for neurologic impairment in thoracolumbar burst fractures[6]
1989	Keene *et al*.	Significance of acute posttraumatic bony encroachment of the neural canal	80	T, TL, L	CT	Negative	The immediate, posttraumatic neurologic status did not directly correlate with the percent of neural canal impingement demonstrated on their CT scans[8]
1991	Braakman *et al*.	Neurological deficit in injuries of the thoracic and lumbar spine. A consecutive series of 70 patients	70	T, TL, L	CT	Negative	The degree of involvement of the cross-sectional area of the spinal canal on first CT, was not correlated with the type and degree of initial neurological deficit[2]
1992	Fontijne *et al*.	CT Scan prediction of neurological deficit in thoracolumbar burst fractures	139	T, TL, L	CT	Positive	Significant correlation between neurological deficit and the percentage of spinal canal stenosis; the higher the level of injury the greater was the probability. But the severity could not be predicted[5]
1994	Rasmussen *et al*.	Reduced transverse spinal area secondary to burst fractures: Is there a relationship to neurologic injury?	65	TL	CT	Positive	A smaller transverse spinal area secondary to burst fractures can be tolerated at successively caudal levels without neurologic deficit[10]
1994	Kang *et al*.	Sagittal measurements of the cervical spine in subaxial fractures and dislocations. An analysis of 288 patients with and without neurological deficits	288	C	PR	Positive	The severity of the injury of the spinal cord was in part associated with the space available for the cord after the injury[7]
2003	Eberl *et al*.	Importance of the cross-sectional area of the spinal canal in thoracolumbar and lumbar fractures. Is there any correlation between the degree of stenosis and neurological deficit?	35	TL, L	CT	Negative	No correlation between the extent of spinal canal stenosis and the degree of the neurological deficit[4]

(Contd...)

Table 4: *(Continued)*.

Year	Author	Title	# Pacients	Segments	Radiology	Association	Conclusion
2007	Dai *et al*.	Neurological recovery from thoracolumbar burst fractures: is it predicted by the amount of initial canal encroachment and kyphotic deformity?	87	TL	CT	Negative	The stenotic ratio of spinal canal or kyphosis angle was not significantly correlated with initial and final ASIA score and recovery rate[3]
2008	Mohanty *et al*.	Neurological deficit and canal compromise in thoracolumbar and lumbar burst fractures	105	TL, L	CT	Negative	The difference between the extent of canal compromise and the severity of neurological deficit at the thoracolumbar and lumbar spine was not significant[9]
2012	Hai Bin	Cervical spinal canal narrowing and cervical neurological injuries	1017	C	PR	Positive	Cervical spinal canal narrowing can lead to spinal cord injuries and neurological symptoms[14]
2013	Aebli *et al*.	Predicting the risk and severity of acute spinal cord injury after a minor trauma to the cervical Spine	182	C	RM, PR	Positive	Patients at risk of acute SCI after a minor trauma to the cervical spine can be identified by applying a disc-level canal diameter cutoff value of 8 mm[1]
2016	Tang *et al*.	Analysis of the independent risk factors of neurologic deficit after thoracolumbar burst fracture	105	TL	TC	Positive	Compression ratio of median sagittal diameter as risk factor of neurologic deficit after thoracolumbar burst fracture[12]

C: Cervical, L: Lumbar, T: Thoracic, TL: Thoracolumbar, MR: Magnetic resonance, PR: Plain radiography, CT: Computed tomography

CONCLUSION

Following sub-axial cervical and thoracic spine traumatic burst fractures, but not lumbar fractures, the extent of CT-documented spinal canal compression positively correlated with the severity of patients' neurological deficits.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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