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

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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]
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., the transversal area of the spinal canal at the fracture level divided by the mean transversal area of the adjacent vertebra [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.

| Characteristic               | 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 invasion* (%)   | 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
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 Fontjine et al., who found a significant correlation between neurological deficit and the percentage of spinal canal stenosis, but the severity could not be predicted. 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] 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][^1][^2][^14]

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

| Year | Author | Title | # Patients | 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] The immediate, posttraumatic neurologic status did not directly correlate with the percent of neural canal impingement demonstrated on their CT scans[^8] |
| 1989 | Keene et al. | Significance of acute posttraumatic bony encroachment of the neural canal | 80 | T, TL, L | CT | Negative | |
| 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[^8] |
| 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...)
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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