

SPINAL BURST-TYPE FRACTURE ON CAUDA EQUINA AREA: CORRELATION BETWEEN NEUROLOGICAL FUNCTION AND STRUCTURAL CHANGES ON SPINAL CANAL

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SUMMARY

Purpose: The purpose of this study was to determine whether a correlation exists between the traumatic narrowing of the spinal canal, potentially associated lamina fractures and the early neurological status of patients presenting to the hospital with burst fractures of the cauda equina area. **Material and methods:** A retrospective review was carried out on 42 patients with 43 burst-type fractures of L3, L4 and L5 treated at a tertiary medical trauma center from January, 1990 to December, 2004. Results were based on comparisons made between the initial neurological deficit and the midsagittal diameter of the fractured vertebrae. **Results:** The only predictive independent

variable of the neurological deficit was the narrowing of the spinal canal ($p=0.008$). The average narrowing of the spinal canal was greater in patients with associated lamina fractures ($p<0.001$). However, multiple independent analyses did not establish lamina fractures as a predictive factor for neurological deficit. **Conclusion:** It was concluded that, in burst fractures of the cauda equina area, the acute traumatic spinal canal narrowing, with or without associated fractures of the lamina, shows a statistically significant positive correlation with the neurological deficit.

Keywords: Spinal Fractures; Spinal injuries; Spinal canal.

Citation: Tisot RA, Avanzi O. spinal burst-type fracture on cauda equina area: correlation between neurological function and structural changes on spinal canal. *Acta Ortop Bras. [serial on the Internet]. 2008; 16(2):85-88. Available from URL: <http://www.scielo.br/jaob>.*

INTRODUCTION

The burst-type fracture occurring in an area limited to the cauda equina represents a small proportion of all spinal burst-type fractures; however, it deserves further attention due to its typical anatomical and biomechanical properties that differentiates it from other spine segments, thus influencing the selection of a therapeutic approach⁽¹⁻⁹⁾. A large amount of patients with spinal burst-type fractures receiving healthcare at the emergency area present with multiple associated traumas, such as craniocerebral trauma and multiple fractures on limbs. In these cases, an effective assessment of the neurological function for an accurate and early therapeutic approach is a challenge. For this prediction, one should know not only the classification of fractures with their types and subtypes, but also value the spinal segment where the fracture occurred. The small amount of studies on burst-type fractures addressing only the cauda equina area, combined with the significant number of cases documented by computed tomography in our service, have motivated us to conduct this research. It is worthy to highlight, also, that we couldn't find published studies with a larger case

series or addressing the same study purpose, which is to verify if a correlation exists between traumatic narrowing of the spinal canal and associated lamina fractures, and the neurological function at early physical examination in patients presenting with burst-type fractures at L₃, L₄ e L₅ levels.

MATERIAL AND METHODS

Between 1990 and 2004, 42 patients were hospitalized at "Pavilhão Fernandinho Simonsen", of Santa Casa de São Paulo, showing acute burst-type fractures on lumbar spine at L₃, L₄ e L₅ levels. One of those patients showed a burst-type fracture at L₄ e L₅ vertebrae, simultaneously. Therefore, the total number of fractures investigated in this study is 43. All these cases were reviewed from data collected from medical files, X-ray images and axial computed tomography films stored at the Medical File and Statistics Service (SAME) of Santa Casa de Misericórdia de São Paulo (SCMSP), according to previously established criteria^(10,11). All cases were documented with X-ray images of the vertebral spine at anteroposterior and lateral planes, as well as axial computed tomography films addressing

Study conducted at the Department of Orthopaedics and Traumatology, School of Medical Sciences, Santa Casa de São Paulo (FCMSCSP)
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Received in: 02/21/07; approved in: 05/05/07

bone tissue and soft parts, with axial sections of 3-5 millimeters thick, perpendicularly oriented to the longitudinal axis of the spinal canal of the fractured vertebra and its adjacent levels. The exclusion criteria were the following: previous neurologic lesion or resultant from vertebral fracture above L₃ level, injuries secondary to gun shots, or fracture on pathological bone. None of the 42 patients fit this profile. The technique for assessing the degree of involvement of spinal canal by protrusion of bone fragment into it was performed with a graded rule in increments of 1 mm, and based on the mid-sagittal diameter⁽¹²⁾. The normal diameter of spinal canal before trauma was estimated by the average of values found in axial sections on the anatomical correspondent of the vertebrae adjacent to fracture site (Figure 1).

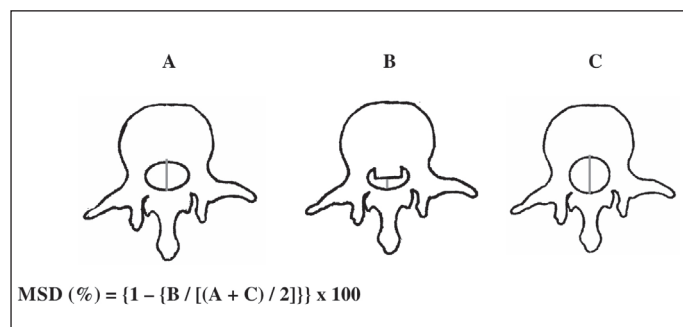


Figure 1 – Illustration of the method for checking the mid-sagittal diameter (MSD) of the fractured vertebra compared to the average on adjacent levels.

The patients were divided according to the classification recommended by Frankel et al.⁽¹³⁾ based on neurological changes. The statistical techniques employed included: descriptive statistics; variance analysis (ANOVA) or Kruskal-Wallis test complemented by the Tukey-HSD test for multiple comparisons; Student's t-test for independent samples; chi-squared association test or Fisher's exact test when at least one of the expected frequencies was lower than 5; multiple logistic regression model, for determining independent predictive factors for neurological compromise. For all tests, the statistical significance level adopted was 5%.

RESULTS

There were 31 male patients (73.8%) and 11 female patients (26.2%). Their ages ranged from 13 to 63, with mean age of 33.5 years.

Mechanisms of trauma included: high falls for 31 patients (73.8%), car accident for 6 patients (14.3%), trampling for two patients (4.8%), motorcycle accident for two patients (4.8%) and 1 patient was injured by the debris of a collapsed building (2.3%). It is interesting to highlight that, of the 31 patients suffering high falls, 7 cases (22.6%) were the result of suicide attempts. Regarding the level of fracture, 23 cases (53.5%) occurred at L₃ level, 14 cases (32.6%) at L₄ level, and six cases (13.9%) at L₅ level. According to the physical neurological examination, 30 patients (71.4%) showed a normal neurological picture (Frankel E), 5 patients (11.9%) Frankel D, 3 patients (7.1%) Frankel C, 4 patients (9.5%) Frankel B, and no patient (0%) with Frankel A.

Early neurological change

A statistically significant difference ($p < 0,001$) was found between the average percentage of spinal canal narrowing on patients with and without changes on early neurological examination. Patients with neurological deficit present at hospital admission showed an increased spinal canal narrowing than the patients with normal neurological tests (Table 1). The amount of narrowing of the spinal canal was assessed according to FRANKEL scale. This study demonstrated the presence of a statistically significant difference between the averages of spinal canal involvement percentage on different grades of that neurological score ($p < 0,001$). In the multiple comparison test, it was found that the real differences on canal narrowing are among the Frankel E and B ($p < 0,001$), and Frankel E and C ($p = 0,017$) neurological grades. Based on the multiple logistic regression equation, the odds ratio for neurological lesions was calculated with stenosis values of 25%, 50% and 75%, using the following equation: $P = 1 / 1 + e^{- (\beta_0 + \beta^1 \cdot x)}$. According to the narrowing values mentioned above, the odds ratio for neurological lesion is 0.15%, 14.11%, and 94.86%, respectively. The only independent predictive variable of neurological involvement was the narrowing of spinal canal.

Early Neurological Examination	Number of Burst-type Fractures	Average of the spinal canal's narrowing percentage
Normal	30	37.2
Changed	13	67.0
Total	43	46.2

$p < 0,001$; Student's t-test.

Table 1 – Mean percentage of spinal canal narrowing, according to the early neurological examination.

Fractures of the lamina

The mean percentage of spinal canal narrowing caused by fractured bone fragment was significantly higher ($p < 0,001$) in cases where a fracture of the lamina was associated (Table 2). From the Odds Ratio, we could predict the chances of a fracture of the lamina to occur associated to a significant involvement of the spinal canal by the bone fragment of a fractured vertebra. It was reported that a lumbar burst-type fracture at L₃, L₄ e L level with over 50% of canal narrowing is 20 times more likely to present an associated fracture of the lamina, when compared to fractures involving a narrowing of less than 50% of the spinal canal (OR = 20.6; $p = 0,001$). A statistically significant association was found between the neurological picture (normal or changed) and fracture of the lamina (present or absent) ($p = 0,002$). Only one of the 13 fractures associated with neurological lesion showed no concomitant fracture of the lamina (Table 3). However, in the multiple analysis, fractures of the lamina were not found to be an independent predictive factor for the occurrence of neurological lesion.

Fracture of the lamina	Number of cases	Mean Spinal Canal Narrowing (%)
Yes	24	58.9
No	19	30.2
Total	43	46.2

p < 0.001; Student's t-test.

Table 2 – Mean spinal canal narrowing according to the presence or absence of fractures of the lamina.

Neurological function (Frankel)	Fracture of the lamina			
	no	%	yes	%
Normal	18	60.0	12	40.0
Changed	1	7.7	12	92.3

p = 0.002; chi-squared test.

Table 3 – Distribution of burst-type fractures according to patients' early neurological function and the presence or absence of fractures of the lamina.

DISCUSSION

Several studies have been conducted with the purpose of correlating the amount of bone fragment on spinal canal with the neurological picture in thoracic and lumbar burst-type fractures. Some of those studies showed that the bigger the bone fragment in spinal canal, the higher the chances of a neurological lesion to occur^(10,12,14-17). Oppositely, some authors reported the inexistence of such direct correlation due to variables that, although not visualized on computed tomography images, would explain a serious neurological lesion without significant narrowing of the spinal canal. These variables would be interstitial injuries, bruises, localized kyphosis, spinal cord section, and intervertebral disc fragments⁽¹⁸⁻²²⁾. By assessing these studies, we noticed that most of them did not sort the burst-type fractures according to the anatomical and biomechanical segment they belong to. The presence of marrow, marrow cone, or cauda equina on spinal canal may distinctively interfere on a patient's neurological function when a particular amount of canal narrowing is present. Similarly, the structural characteristics of fractures occurring in a kyphosis segment may differ from those occurring on a lordosis segment and, as a result, may also influence neurological function. The average percentage of traumatic acute narrowing of the spinal canal occurred secondarily to bone fragments of the fracture was high (46.2%). This value is significantly higher than the values for spinal canal narrowing at thoracic and thoracolumbar segments found by several authors^(16,17,23). We believe that this higher average percentage of involvement of the spinal canal at L₃, L₄ and L₅ level can be justified by the physiological lordosis presented by these lumbar vertebrae. No neurological damages were seen on 30 patients included in the present study (71.4%). An et al.⁽⁴⁾ showed that, in their 31 patients with burst-type fracture at L₃, L₄ e L₅ level, 18 were initially neurologically intact (58,1%). Seybold et al.⁽²⁾, assessing 42 patients with this kind of fracture at L₃, L₄ and L₅ level, reported that 24 patients initially presented with no neurological damages

(57.2%). These data reinforce the idea that most of the patients victims of burst-type fractures at the cauda equina level have no associated neurological lesion, because the cauda equina is less sensitive to extrinsic pressure than spinal cord and medullar cone areas. The FRANKEL scale, although widely used in clinical practice due to its ease of use, is more indicated in injuries located above the medullar cone. On the cauda equina area, its use may not reflect the actual severity of a patient's neurological damage. Furthermore, the classification of patients according to the various categories in this scale may also challenge the statistical validation of the results⁽¹⁵⁾. There isn't also a simple and direct correlation between neurological damage, as measured by FRANKEL score, and morbidity, from a functional point of view, presented by patients suffering burst-type fractures on cauda equina area. We believe that, for an appropriate functional assessment, other neurological scores could be discussed. In the present study, however, the FRANKEL score was shown to be effective in presenting a direct correlation with the percentage of spinal canal involvement. According to Holdsworth^(24,25), the burst-type fracture was regarded as a stable injury, without lesion on the posterior ligament complex or associated posterior arc fractures. Nevertheless, according to Whitesides⁽²⁶⁾, a full injury of the posterior ligament complex could occur in association to a severe comminution of the vertebral body (unstable burst-type fracture). Computed tomography started to be used for providing an accurate diagnosis of burst-type fracture⁽²⁷⁾ and, the associated fracture of the lamina – at that time difficult to be diagnosed on a plain X-ray image, started to draw the attention of several authors^(10,28,29). In the present study, we were impressed with the finding that most of the patients assessed here had an associated fracture of the lamina. As previously mentioned, of the 43 burst-type fractures, 24 had an associated fracture of the lamina (55.8%). Cammisa et al.⁽³⁰⁾, evidenced that 30 (50%) of 60 patients studied presenting thoracic and lumbar burst-type fractures and surgically treated, showed fractures of the lamina. If we consider only the cases submitted to surgical treatment which presented with this kind of fracture, the incidence rate, in our study, rises to 78.3% of the cases. We believe that this significant incidence of laminar fracture associated to low lumbar burst-type fractures is a result of the physiological lordosis in which this region is included. An axial trauma causing a burst-type fracture on L₃, L₄ and L₅, implies on a stronger impact to the posterior region of these vertebrae bodies. Consequently, a stronger bone fragmentation occurs near spinal canal, causing an increased interpedicular distance. This separation of the pedicles causes a higher incidence of laminar fracture. Additionally, if no flexion force associated to axial trauma exists and the vertebral collapse is important, we believe that a posterior arc fracture may occur, even due a direct trauma with adjacent arcs. The results obtained in this study reinforce those ideas, because the average bone narrowing on spinal canal was significantly higher on patients presenting with fractures of the lamina (58.9%). In patients not presenting this associated fracture, the average bone narrowing on spinal canal was as low as 30.2%. In addition, according to body's gravity line, L₄ is apparently the vertebra presenting the highest level of physiological lordosis, and thus, as expected, it was the vertebra with the highest average of spinal canal compromised by fracture fragments (49.5%), and the higher amount of associated laminar fractures as

well (37.5%), although these values were not significantly different. All patients presenting with early neurological damages showed an associated laminar fracture; however, not all patients with fractures of the lamina showed early neurological changes. Furthermore, it was curious to find that the average of traumatic acute narrowing of the spinal canal was significantly higher in patients with early neurological damages associated to laminar fracture when compared to those neurologically normal patients with and without this kind of associated fracture. These data reinforce that, the higher the energy irradiated to the vertebra the higher the chances that a bone fragment is driven towards spinal canal, and, consequently, the higher the likelihood of a laminar fracture. These structural changes on the spinal canal increase, as a result, the incidence of lesions on cauda equina area. However, we must highlight that, in the present study, fractures of the lamina were not regarded, alone, as a predictive factor for neurological lesions. It reflects, on the multiple analysis, the real factor interfering on neurological function, which is the narrowing of the spinal canal. We cannot state, in this study, that the failure to include laminar fracture as an independent predictive factor was due to the small number of cases showing neurological damages (samples size), which, as a result, could reflect in a low statistical power for multiple regression. The sample and individual vari-

ability, as well as the biological behavior on the studied area, could also be related with this statistical result. Therefore, in multiple-trauma patients with burst-type fractures on low lumbar spine, in whom the early neurological examination of the lower limbs is compromised, the measurement of the mid-sagittal diameter of the spinal canal, on computed tomography image, serves as a reliable parameter to estimate neurological function. Should the estimated spinal canal narrowing is below or equal to 50%, regardless of the presence or absence of laminar fracture, the likelihood of a lesion to be present on cauda equina is small.

CONCLUSION

The traumatic acute narrowing of the spinal canal caused by a fractured bone fragment, with or without associated fractures of the lamina in burst-type fractures on cauda equina area has a direct and statistically significant correlation to neurological function changes.

ACKNOWLEDGEMENT

We acknowledge the Publications Support Nucleus of the Medical Sciences School, Santa Casa de São Paulo - NAP-SC for the technical-scientific support to the publication of this manuscript.

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