

Thoracolumbar burst fracture: what the radiologist should know*

Fratura toracolombar do tipo explosão: o que o radiologista deve conhecer

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Abstract Thoracolumbar burst fractures are defined as those fractures involving compromise of the anterior, middle and posterior vertebral columns. The treatment for such vertebral fractures still remains undefined, raising questions about the best form of intervention in these cases. Because of these doubts, imaging methods play a key role in the preoperative workup. However, several tests and measurements are performed by spine surgeons before deciding on the best approach to be adopted, with no standardization and neither consensus. The present review was aimed at standardizing and describing the main techniques and radiological findings on the basis of instability criteria adopted by surgeons in the assessment of thoracolumbar burst fractures, namely extent of height loss of the anterior wall of the fractured vertebra, level of spinal canal compromise by bone fragments and degree of widening of interspinous and interpedicular distance. It is the authors' opinion that the standardization of the main measurements in the evaluation of thoracolumbar burst fractures by radiological methods will provide the information required for a better interpretation of tests results and consequently aiding in the decision making about the most appropriate treatment.

Keywords: Radiology; Fracture; Spine.

Resumo As fraturas vertebrais do tipo explosão são definidas como fraturas nas quais ocorre comprometimento da coluna anterior, média e posterior da vértebra. O tratamento destas fraturas vertebrais persiste indefinido, gerando questionamentos quanto à melhor forma de intervenção destes pacientes. Devido a estas dúvidas, os métodos de imagem apresentam papel fundamental na propedêutica pré-operatória. No entanto, diversas análises e mensurações são realizadas pelos cirurgiões de coluna sem padronização e consenso antes de se decidir sobre a melhor abordagem destes casos. Nesta revisão temos como objetivo padronizar e descrever as principais técnicas e achados radiológicos, com base nos principais critérios de instabilidade utilizados pelos cirurgiões na avaliação da fratura toracolombar tipo explosão, sendo eles, a medida da perda da altura da parede anterior da vértebra fraturada, a porcentagem de fragmento intracanal e o grau de abertura da distância interespinhosa e interpedicular. Acreditamos que, ao padronizar as principais mensurações realizadas para avaliação das fraturas toracolombares do tipo explosão por meio dos métodos radiológicos, estaremos fornecendo informações necessárias para a melhor interpretação dos resultados dos exames e, consequentemente, para uma tomada de decisão mais adequada acerca do tratamento.

Unitermos: Radiologia; Fratura; Coluna vertebral.

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INTRODUCTION

Thoracolumbar burst fracture was first described by Sir Frank Holdsworth, in 1963⁽¹⁾, as an injury typically resulting from fall from height or motor vehicle accidents, causing a significant axial load on the spine, leading to a failure by compression of the anterior, middle and posterior verte-

bral columns⁽²⁾. Most burst fractures occur at the level of the thoracolumbar junction whose vulnerability is partially explained by the anatomic and biomechanical features of the region. Such an explanation is due to the radial shape of the thoracic cage and stability provided by the costotransverse ligaments in the thoracic spine which give a higher resistance to load in the coronal and sagittal planes, and to axial rotation. Such a protection degree and the relatively rigid shape contrast with the underlying lumbar spine – more flexible and less protected than the thoracic spine –, resulting in a fragile segment that is named thora-

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columbar transition (T11-L2)⁽³⁾. In a specific study developed by Avanzi et al.⁽²⁾, 83% of injuries have occurred between T12 and L2, the first lumbar vertebra being the most affected, likewise in studies developed by other authors⁽⁴⁻⁷⁾.

Currently, there is a consensus in the medical literature about the best approach to be adopted in the treatment of vertebral fractures types such as luxation, flexion/distraction and wedge fractures, but not on the treatment of burst fractures, since most patients neither present neurological deficit nor meet direct instability criteria^(2,3,8-10). So, the decision making process about the best treatment to be adopted for thoracolumbar burst fractures is based on indirect vertebral instability criteria^(2,5,11-13).

The main instability criteria adopted by spine surgeons to evaluate burst fractures are the following: extent of height loss of the anterior wall of the fractured vertebra, level of spinal canal compromise by bone fragments, degree of kyphosis, and degree of widening of interspinous and interpedicular spaces^(2,11-14).

Based on such criteria which have already been defined by the literature, surgeons can determine the likelihood of vertebral collapse and progression to late neurological deficit, besides estimating the post-treatment residual pain, and also to change de fracture classification, considering that for each criterion there is a question to be answered before the definition of the treatment.

The motivation for developing the present study is the necessity of standardizing and diffusing the main treatment techniques and radiological findings, with basis on the main spinal instability criteria utilized by surgeons in the assessment of thoracolumbar burst fractures, with the objective of helping them to define the best form of management for these patients

MATERIALS AND METHODS

Radiological routine

In a systematic fashion, the authors started the radiological workup to evaluate patients with suspected thoracolumbar burst fracture utilizing posteroanterior (PA) and lateral views of spine radiography. Posteroanterior (PA) view allows the measure-

ment of widening of interspinous and interpedicular spaces, according to the Neumann's method⁽¹³⁾.

The calculation of the degree of widening of interpedicular space of the injured vertebra is based on the average of interpedicular spaces between the fractured vertebra and the immediately superior and immediately inferior vertebrae^(2,12), corresponding to the rate of widening of the interpedicular space (Figure 1). The measurement of the interpedicular space was performed with a transparent ruler with a millimeter scale.

Also on the PA view, the Neumann's method⁽¹³⁾ allows the measurement of the variation of the distance between the spinous processes which constitutes an indirect sign of injury to structures of the posterior spinal column. The method con-

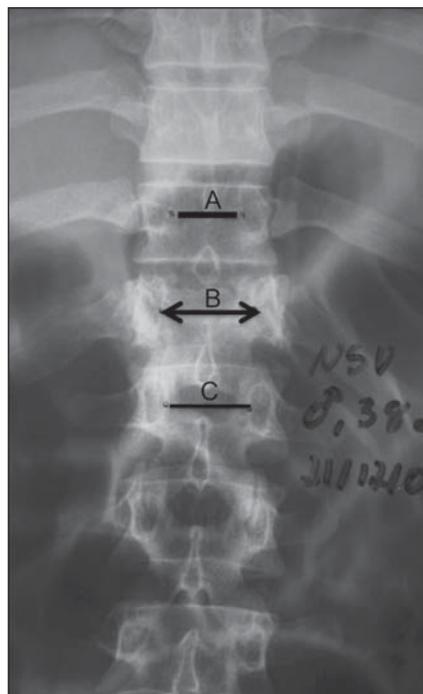


Figure 1. Calculation of interpedicular distance. Postero-anterior radiography of thoracolumbar spine demonstrating interpedicular distances at the level of the fracture (B) and between the injured vertebra and the immediately superior and immediately inferior vertebrae (A and C, respectively). The mean interpedicular distance is calculated by subtraction of the interpedicular distance at the level of the fractured vertebra on the average between the interpedicular distances of the vertebrae immediately superior and immediately inferior to the fractured vertebra, multiplied by 100, according to the following formula: $\{(A+C)/2 - B\}/(A+C)/2 \times 100$. Example: A = 2.0 cm, B = 3.0 cm, C = 2 cm; so, $\{(2+2)/2\} - 3/(2+2)/2 = -1/2 = 50\%$.

sists in marking the distance from the upper border of the spinous processes projected on PA radiographs. Variations of up to 7 mm in the distance is considered as normal, also allowing the calculation of the percentage of spinous processes widening, with 20% being considered as unstable posterior ligamentous complex, requiring surgical treatment (Figure 2).

Continuing the radiological evaluation, the authors utilized the lateral view of the spine which allows the evaluation of the rate of height loss of the anterior wall of the vertebra affected by compression fracture. For this purpose, the authors utilized the method developed by Willén et al.⁽¹¹⁾, utilizing the average between the heights of the vertebral bodies immediately superior

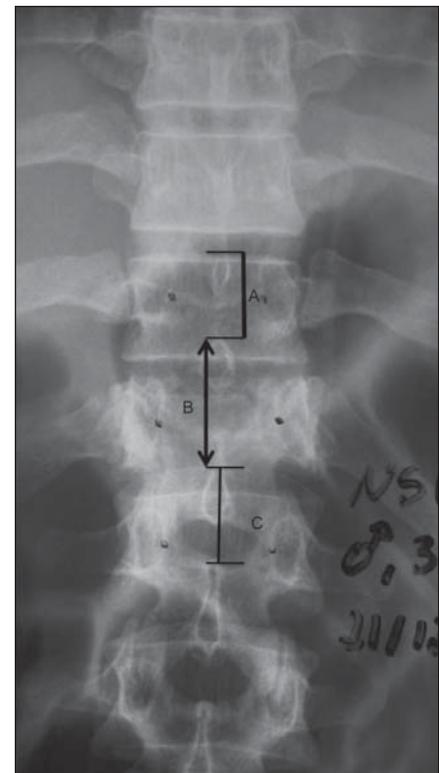


Figure 2. Calculation of the interspinous distance. Postero-anterior radiography of thoracolumbar spine demonstrating the distances between spinous processes at the level of the fracture (B) and at the superior and inferior levels (A and C, respectively). The mean interspinous distance is calculated by subtraction of the interspinous distance at the level of the fractured vertebra on the average between the interspinous distances of the vertebrae immediately superior and immediately inferior to the fractured vertebra, multiplied by 100, according to the following formula: $\{(A+C)/2 - B\}/(A+C)/2 \times 100$. Example: A = 2 cm, B = 3 cm, C = 3 cm; so, $\{(2+3)/2 - 3\}/(2+3)/2 = -0.5/2.5 = 20\%$.

and inferior to the fractured vertebrae to obtain the rate of height loss of the anterior wall of the fractured vertebra (Figure 3).

Continuing the imaging workup, the utilization of computed tomography may pro-

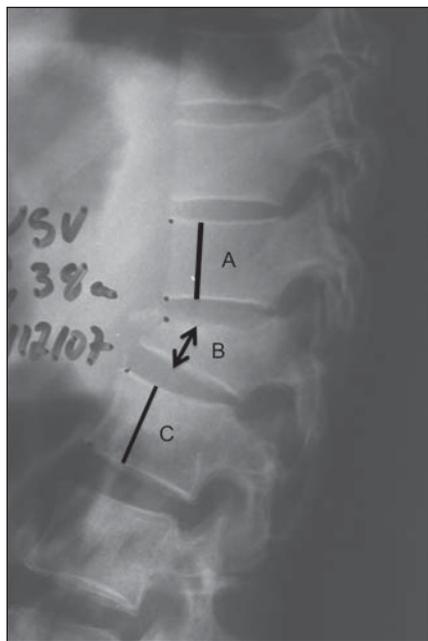


Figure 3. Calculation of vertebral bodies height. Lateral radiography of thoracolumbar spine demonstrating the height of the anterior wall of the fractured vertebral body (B) and of the vertebral bodies immediately superior and immediately inferior to the fractured vertebra (A and C, respectively). The average between the superior and inferior vertebral bodies is calculated by subtraction from the height of the fractured vertebral body, on the average between the heights of the superior and inferior vertebral bodies, multiplied by 100, according to the following formula: $\frac{\{(A+C)/2 - B\}}{(A+C)/2} \times 100$. Example: A = 3 cm, B = 2 cm, C = 3 cm; so, $\frac{\{(3+3)/2 - 2\}}{(3+3)/2} = 1/3 = 33\%$.

vide data regarding the fracture trace analysis and evaluation of the involvement of the vertebra components, with possibility of utilizing sagittal and coronal image reconstructions. Such method allows a highly accurate assessment of the vertebral canal compromise by bone fragments (retropulsion of the posterior wall of the vertebral body) by measuring the mid-sagittal diameter, as proposed by Trafton and Boyd, in 1984⁽¹²⁾, and of the presence of lamina fracture.

The evaluation of the percentage of vertebral canal stenosis as proposed by Trafton and Boyd is based on the average between the values found on axial CT sections of the superior and inferior vertebrae adjacent to the affected vertebra. The evaluation of the neural canal narrowing produced by burst fracture was performed by measuring the mid-sagittal diameter of the canal on CT sections at the level of the affected vertebra, expressed as a percentage in comparison with the adjacent levels (Figure 4).

At CT, it is also possible to evaluate the presence or not of laminar fracture, which may be related to the severity of the trauma and associated with a higher risk for neurological involvement (Figure 5)⁽¹⁰⁾.

DISCUSSION

There remains considerable difficulty in determining the best treatment for thoracolumbar burst fractures, generating debate in several medical schools. Because of such uncertainty, some authors have created in-



Figure 5. Lamina fracture. Axial computed tomography section demonstrating burst fracture of the last dorsal vertebra. Lamina fracture is highlighted at left (arrow).

stability criteria based on objective measurements to support the indication of the most appropriate treatment.

In the present article, the authors describe the main radiological methods and findings both at radiography and computed tomography, justifying the relevance of the utilization of objective measurements for both medical first responders and spine surgery specialists. Based on such standardization, the radiologists will be able to adopt such criteria in their reports, in practice, contributing to the indication of the treatment for these patients, since lesions considered as stable are likely to be conservatively treated with the use thoracolumbosacral orthoses, and fractures considered as unstable require surgery for stabilization with pedicle screws.

The measurement of the degree of interpedicular widening on PA radiographs is

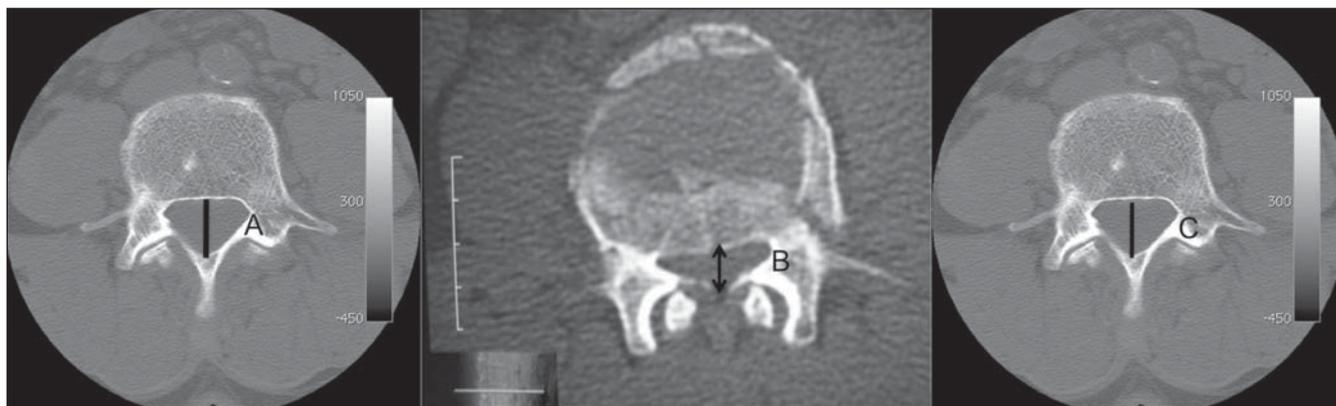


Figure 4. Calculation of anteroposterior distance of the vertebral canal. Computed tomography of vertebral spine demonstrating the anteroposterior diameter of the vertebral canal at the level of the fractured segment (B) and of the vertebral canal at the superior and inferior levels (A and C, respectively). The mean diameter of the vertebral canal at the level of the immediately superior and immediately inferior vertebrae was calculated by subtraction from the diameter of the vertebral canal at the level of the fracture, on the average between the vertebral canal diameters of the superior and inferior segments, multiplied by 100, according to the following formula: $\frac{\{(A+C)/2 - B\}}{(A+C)/2} \times 100$. Example: A = 4 cm, B = 2 cm, C = 4 cm; so, $\frac{\{(4+4)/2 - 2\}}{(4+4)/2} = 2/4 = 50\%$.

extremely relevant for allowing a correct classification of burst fractures (Denis classification for involvement of middle and anterior columns) which require greatest care and enhanced radiological investigation by means of computed tomography. In 1992, Mumford et al. described a direct relation between percentage of vertebral canal compromise and interpedicular widening visualized at plain anteroposterior radiography, suggesting that the interpedicular widening occurs in burst fractures. Such data is extremely relevant for the medical first responder because, after the identification of interpedicular widening in the fracture, its classification changes from wedge fracture to burst fracture, requiring enhanced care with the patient⁽⁷⁾.

On the other hand, the degree of interspinous widening, also measured at PA radiography, indirectly evaluates the risk for severe posterior ligament injury, which might change the classification of the fracture from burst fracture to flexion/distraction fracture, determining the type of treatment to be adopted. The most utilized method for measuring interspinous widening is the one proposed by Neumann⁽¹³⁾, considering a widening > 7 mm as pathological. Also, an interpedicular widening > 20% can be utilized as a reference value, as already reported in the literature⁽¹³⁾. Magnetic resonance imaging is the gold standard for the diagnosis of posterior ligament injury, but this method is not widely available in many hospitals.

The evaluation of the intracanal fragment percentage is extremely important, since the degree of compromise may lead or not neurological involvement, directly depending on the percentage of decrease in the vertebral canal width. According to

Meves & Avanzi, the neurological conditions of patients with burst fracture were directly associated with vertebral canal narrowing⁽¹⁵⁾. Trafton & Boyd⁽¹²⁾ have reported that thoracolumbar spine fractures with narrowing of the middle-sagittal diameter = 50% resulting from retropulsed fragments associated with lamina fracture present a significant risk for neurological deficit.

Lamina fracture is other finding evaluated at computed tomography. Such a finding suggests that the impact of the trauma was distributed among the three columns, so increasing the probability of neurological involvement⁽⁵⁾. Tisot & Avanzi⁽¹⁰⁾ have observed that the mean percentage of vertebral canal narrowing caused by the presence of bone fragments was significantly higher in cases of association with lamina fracture. Such finding has represented an important data to be investigated at computed tomography (Figure 5) because of the association between lamina fracture and dural tears.

CONCLUSION

The authors highlight the extreme relevance of the radiologists' knowledge of the main criteria e measurements utilized by spine surgeons, as well as on the adoption of such data in the determination of treatment for thoracolumbar burst fractures, allowing their inclusion in the radiological workup and routine radiological reports.

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