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Revisão

Importance of load sharing column and canal violation in the management of thoracolumbar burst fractures. A review

Importância da coluna de suporte de peso e da compressão do canal vertebral na conduta das fraturas-explosão toracolombares. Revisão

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ABSTRACT

Introduction: *The ideal classification of spinal fractures should include every kind of fracture and suggest patterns of treatments. Vaccaro et al. proposed a classification and treatment rules according to a comprehensive severity score. In this one, fractures with exclusive lesion of the vertebral body, burst fractures, without either damage of the posterior ligament band or neurological deficit, are considered for conservative treatment.* ***Objective:*** *To demonstrate that some fractures, with an exclusive lesion of the load sharing column, the vertebral body, without any posterior ligament destruction, may be unable to share physiological loads and if associated with great compression of spinal canal, carries so much risk of neural damage that it should be submitted to surgery.* ***Methods:*** *This review is based on the discussion of the literature and is illustrated by a case description.* ***Results:*** *We demonstrate the importance of inclusion of the concepts, load sharing column and intensity of canal encroachment in therapeutic decision regarding thoracolumbar fractures.* ***Conclusions:*** *Patients with canal compression 50% should be considered for surgery. Patients with lesser degrees of canal encroach may be submitted to erect radiography and operated if there is an additional loss of vertebral body height or neurological symptoms.* ***Key-words:*** *Thoracolumbar fracture; load sharing classification; burst fracture, canal encroachment.*

SUMÁRIO

Introdução: *Uma classificação ideal de fraturas da coluna vertebral deve incluir todo tipo de fratura e sugerir padrões de tratamento. Vaccaro et al. propuseram uma classificação e regras de tratamento de acordo com um escore de gravidade da lesão. Nesta, fraturas com lesão exclusiva do corpo vertebral, fraturas-explosão, sem lesão ligamentar posterior ou déficit neurológico são consideradas para tratamento conservador.* ***Objetivo:*** *Demonstrar que algumas fraturas, com lesão exclusiva da coluna de suporte de peso, corpo vertebral, sem qualquer dano ligamentar posterior podem ser incapazes de suportar cargas fisiológicas e, se associadas a grande compressão do canal vertebral, apresentam risco de dano neurológico, devendo ser operadas.* ***Métodos:*** *Esta revisão é baseada na discussão da literatura e é ilustrada pela descrição de um caso.* ***Resultados:*** *Nós demonstramos a importância da inclusão dos conceitos, grau de lesão da coluna de suporte de peso e intensidade da compressão do canal vertebral, na decisão de conduta nas fraturas toracolombares.* ***Conclusões:*** *Pacientes com compressão do canal 50% devem ser considerados para cirurgia. Pacientes com graus menores de compressão do canal podem ser submetidos a radiografias na posição ereta e operados se houver perda adicional de altura do corpo vertebral ou início de sintomas neurológicos.* ***Palavras-chave:*** *Fratura toracolombar, classificação load-sharing, fratura-explosão, compressão do canal.*

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Introduction

An ideal classification of spinal fractures should include every kind of fracture and suggest patterns of treatment. Historically, there have been several classification schemes of thoracic and lumbar fractures. Two of the most commonly used thoracolumbar (TL) fracture classifications of the last decade are the Denis and Magerl's classifications[16]. The Magerl's classification (AO) has gained wide acceptance but this complex scheme makes it difficult to obtain agreement among different analyses, lowering inter-observer and even intra-observer agreement[13].

Vaccaro et al. recently proposed a "New Classification of Thoracic and Lumbar Fractures" based on fracture morphology, integrity of the posterior ligamentous complex and neurological deficits (Table 1). They described three kinds of fractures: A (compression), B (Translation/rotation) and C (Distraction). A comprehensive description of all types of vertebral fractures was not included. Instead, proposed treatment rules, according to a comprehensive severity score (Table 2). By this system, fractures with exclusive lesions of the vertebral body and burst fractures without damage to the posterior ligament band or neurological deficit are considered for conservative treatment[16].

Table 1. Vaccaro`s Comprehensive Severity Score[16]

Injury Morphology		
Type	**Qualifiers**	**Points**
Compression		1
	Burst	1
Translation/Rotation		3
Distraction		4
Integrity of PLC		
PLC disrupted in tension, rotation or translation		**Points**
Intact		0
Suspected/Indeterminate		2
Injured		3
Neurologic Status		
Involvement	**Qualifiers**	**Points**
Intact		0
Nerve root		2
Cord, conus medullaris	Complete	2
	Incomplete	3
Cauda equine		3

Our objective is to demonstrate that some fractures, with exclusive damage to the load sharing column or the vertebral body and without any posterior ligament lesions, may be unable to share loads. Such fractures associated with great compression of spinal canal, carry risk of neural damage and should be submitted to surgery. This review is based on discussion of the pertinent literature and illustrated by a case description.

Case illustration

A 66-years-old woman, with an eight day- history of a fall from three meters height that resulted in a direct blow to both feet. The patient was referred to our institution after being treated for an L1 fracture with a vest only. In despite of complaining back pain, she was walking normally without any neurological deficit, when she presented with urinary and faecal incontinence and perineal anaesthesia.

The patient had a first radiographic examination done on the day of her fall. There was an L1 burst fracture with a height loss of 30% compared to the L2 vertebral body. Violation of the posterior vertebral line was already evident at the initial radiography (Figure 1A)[5].

Figure 1. (A) Radiography at the moment of the first attendance. There is a L1 fracture with loss of 30% of the vertebral body height (VBH). The posterior vertebral line (PVL) is already violated (arrow). (B) Radiography 8 days later: There is a loss of 56% of VBH and a more obvious violation of the PVL. (C) Anteroposterior radiography. Note the enlargement of the interpedicular distance (arrow). (D) Computed tomography scan (sagittal reconstruction): Note that the vertebral body fracture transposes both endplates and the whole vertebral body. Note the 60% spinal canal encroachment (arrow).

We initiated treatment with the new installed neurological deficit, and the radiography obtained is shown in fig. 1B, C. There was additional loss of height of the L1 vertebral body and a more obvious violation of the posterior vertebral line (Figure 1B). The anteroposterior radiography showed an enlargement of the interpedicular distance at the L1 level suggesting a burst fracture (Figure 1C). Computed Tomography (CT) demonstrated the spinal canal compressed at the L1 level by bone fragment with a canal encroachment of 60% (Figures 1D, 2). She was submitted to surgery three days later and presented with complete improvement of the neurological deficits.

Magnetic resonance (MRI) images of the thoracolumbar spine showed a complete decompression of the spinal canal without

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any kyphosis and or evidence of lesion of the posterior ligament column (Figure 3).

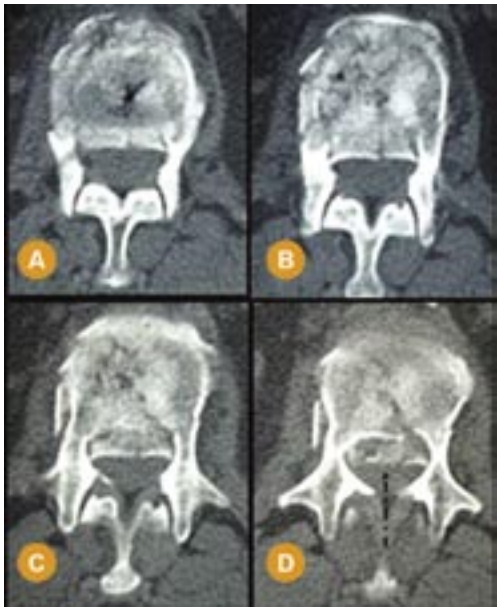

Figure 2. Axial view from bottom (A) to top (D). Note the bone fragment causing spinal canal compression (arrow).

Figure 3. From left to right: post-operative anteroposterior radiography, lateral radiography and post-op MRI. There is no evidence of posterior ligamentous complex lesion.

Discussion

The spine fracture classifications are based on the instability concept. However, this concept, which is a very important factor for the choice of treatment method, is not fully understood1. Holdsworth's classification, considered the first one in modern era, differentiated between stable (simple wedge fractures, burst fractures, and extension injuries) and unstable injuries (dislocation, rotational fracture-dislocation, and shear fracture), as did AO and Vaccaro's classification[8,10,16]. While the risk of neural damage in the acute phase of management of unstable injuries was emphasized, the potential for instability of a certain group of fractures, the burst fractures, was ignored[11].
Little disagreement has been found in the surgical indications of fractures that disrupt the posterior ligament column (Table1 and 2). The translation/rotation and distraction (types B and C according to Vaccaro's) should be treated by posterior approach (Table 2), depending on the additional presence of destruction of the anterior columns and neurological deficit. We have no disagreement related to the classification and rules for treatment in groups B and C of Vaccaro's. The presence of neurological deficit is another point of no discordance. Those patients with incomplete lesions and anterior canal compression should be submitted to the anterior procedure according to Vaccaro's suggestions (Table 2).

Table 2. Vaccaro`s Suggested Surgical Approach[16]

Neurologic Status	Posterior Ligamentous Complex	
	Intact	Disrupted
Intact	Posterior approach	Posterior approach
Root injury	Posterior approach	Posterior approach
Incomplete SCI or cauda equine	Anterior approach	Combined approach
Complete SCI or cauda equina	Posterior (anterior)* approach	Posterior (combined)* approach

* Aggressive decompression in ASIA A patients is practiced in many institutions to optimize. Any potential for neurologic recovery, reconstruct the vertebral support column, restore CSF flow to prevent syringomyelia, and allow for short segment fixation.

Note that there isn't a suggested approach for fractures with exclusive injury of the weight support column.

The majority of classification systems are based on two- column concepts[9,19]. Denis' classification proposed a virtual subdivision of the vertebral stability system into three columns, introducing the concept media column (6). Denis postulated that burst fractures, as it committed two columns, were unstable and should be operated on[6,7].

A group coordinated by Magerl, based on the AO schemes for long bone fracture classification, proposed the Comprehensive classification of thoracic and lumbar injuries[10]. This is, in fact, a comprehensive one, and is comprised by more than 50

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subtypes of fractures. Magerl's classifications, based on a two-column model, states adequately that only group "A" fractures may be stable. As a descriptive classification, they described all types of fractures but didn't discuss the relevance of the degree of vertebral body involvement (comminution) and the compression of spinal canal.

Vaccaro et al[16] proposed a more reproductive classification based on the fracture morphology, integrity of the posterior ligament complex and neurological deficits: they described the morphometry of three kinds of fractures: A (compression), B (Translation/rotation) and C (Distraction). Vaccaro et al[16] classified the distraction group of fractures to be more unstable than the rotation group. This classification didn't describe all types of fractures but suggested treatment rules, according to a severity score, calculated by each of the subgroups in the three main injury characteristics: morphology; integrity of the posterior ligament injury and neurological status as described in table 1 and 2. Each category has an injury numerical hierarchy value associated with it. One to four points: (1 point = least severe; 4 points = most severe) are assigned to reflect the degree of severity. According to these scores, three or less points suggests a non-operative injury, while a score of 5 or more suggests that surgical intervention may be considered. Injuries assigning a total score of 4 should be handled conservatively or surgically[16]. Vaccaro's classification places that injuries with morphology in compression and burst, with no injury of the posterior ligament column or neurological damage are submitted to conservative treatment. Vaccaro also suggests the surgical approach (Table 2)[16].

The reported case is a frequent type of burst fracture, initially with little loss of vertebral height and no kyphosis, without any evidence of distraction of the posterior column (Fig.1). The upper and lower endplates were broken with canal compression at the upper vertebral body (Denis B). These fractures are caused by axial load mechanism. The X-rays taken after 8 days, at the installation of the neurological deficit, revealed additional loss of vertebral height and evident spinal canal compression. There were no kyphosis or signals of a posterior distraction. Pos-op MRI shows no injury of the posterior ligaments (Fig. 3). According to Vaccaro et al[16], the described case, without injury of the posterior ligament column or neurological damage, would be scored as 2 and should not be operated on, as initially not made. Under conservative treatment a neurological damage was installed, with sphincter disturbance and loss of the perineal sensitivity. According to the classical definition of White & Panjabi[18], a fracture that in physiological conditions presents with neurological damage is unstable and the surgery should have the potential to prevent the appearance of the neurological damage.

The load-sharing column theory has received specifically more attention in recent times[2]. McCormack, Karaikovic and Gaines described the Load Sharing Classification (LSC)[12] following patients with fractures operated on with the use of pedicle screws and had got failure of the fixation system. They identified three risk factors for failure: major comminution of the vertebral body, larger separation of the fragments and the final correction of kyphosis made by the surgery; they also quantified the intensity of the load sharing column damage introducing scores from 1 to 3 to the intensity of the damage. A total score greater than 6 is related to a mechanical incompetence of the load sharing column, where a reconstruction is necessary. They proposed the LSC as a guide to drive the need of an anterior reconstruction in the treatment of vertebral fractures. It's suggested that it could be even used in the decision between conservative or surgical approaches. The concept of the LSC, bred from the availability of CT, gained greater refinement after the MRI. Oner et al. had prospectively studied the complications and failures of conservative and surgical treatments. They demonstrated that an unfavourable outcome in the conservative group was related to the progression of kyphosis, which in most cases was predictable with the use of trauma MRI findings concerning the endplate fracture and vertebral body involvement. The authors recommend the use of MRI to develop reliable prognostic criteria for these injuries[14].

In 1995, Wakefield et al postulated the theory of vertebral body cubes. He considered the vertebral body composed of 27 cubes of equal-size. This theoretical model assumes posterior spinal stability. Horizontal disruption of the middle third, viewed in the sagittal glides, and resection of the most ventral cubes (anterior columns) may result in loss of stability[17].

Al-Khalifa et al., studying specifically burst fractures in the thoracolumbar and lumbar spine, demonstrated that a pattern of vertebral collapse can be anticipated[3].

Mehta et al. analyzed the behaviour of the vertebral fractures submitted to early erect radiographs, in the acute phase of the trauma. The mean previous vertebral compression percentage increased from 34% to 46% and the mean supine Cobb angle increased from 11 to 18 on weight-bearing films. They stated that performing erect radiographs in patients with thoracolumbar burst fractures without a neurological additional deficit provides information and alters the management plan in significant proportion (25%) of our patients. They introduced a new test for the weight bearing capacity at the acute stage of the trauma[13].

The role of the spinal canal compression cannot be neglected, mainly associated with a mechanical incompetent fragmented vertebral body. The vertebral body occupying the canal places neural structures at risk, conditions it to a neurological instability[6,7].

Denis et al. (1984) reported six patients who deteriorated neu-

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rologically among 29 burst fractures conservatively treated cases[7].

Whitesides and Kelly recognized unstable burst fractures as being "the most common cause of neural injury in the thoracolumbar region", and they developed a classification system based on a two-column structure - an anterior weight-bearing column of vertebral bodies and a posterior column of neural arches resisting tension. Injuries presenting with late instability could be incorporated into their scheme[9,19].

Willen et al., in conservative management of 54 patients with thoracolumbar (T12 and/or L1) burst fractures, observed that although most types A and B fractures (according to Denis) showed good results, severe type B (with anterior column compression and spinal canal narrowing exceeding 50%) were in a large extent complicated by intractable low back pain, neurological involvement, and signs of instability. This study suggests predictors of complication in patients with burst fractures in the thoracolumbar junction[20]. In the current days, any proposal of treatment should be based on the prospective randomized trials (PRT), comparative results of the diverse effected treatments[4].

There are two PRT papers with conflicting results, comparing to the conservative and surgical treatment of thoracolumbar burst fractures.

In 2003, Wood and col. concluded that operative treatment of patients with a stable thoracolumbar burst fracture and normal findings, on the neurological examination, provided no major long-term advantage compared to a no operative treatment[22]. This was the first PRT comparing to the two kinds of treatments and considered Level of Evidence II-2 (poor-quality randomized controlled trial [e.g., <80% follow-up]).

In 2006, Siebenga and col. published a prospective study comparing to conservative and surgical treatment of patients with thoracolumbar fractures (T10-L4). In the group of the conservative treatment, one out of 15 patients evolved with conus syndrome and urinary dysfunction. The evolution of the described patient was very similar to the one described patient case. The radiographic examination initially showed fractures with little loss of height. CT scan showed burst fracture and a visible gap inside the vertebrae. There was a later loss of vertebral height and neurological deficit. The published image would have received two points in Vaccaro's score and according to it, this type of injury would not have been operated on. We strengthen that the early surgery could have prevented the occurrence of the neurological damage. Siebenga et al. concluded that, excluding the group with simple wedge fractures, the compressive fractures A2 and A3 (classified according to Magerl) have got better results when treated by surgery than by conservative treatment. No patient in the operated group got worse. The authors have argued that, although the pedicle screw is unable to share loads, the final result has no relation with the final kyphosis, and the operated patients had lesser kyphosis than the ones not operated on. They do not consider justified the anterior approach because of an estimated bigger morbidity[15].

The different results in the studies of Siebenga and Wood probably reflect the differences of the studied population , the methodologies of the study and the kind of analysed treatments .

Not all burst fractures should be operated on or receive a conservative treatment. Based on these unique studies, with a small number of patients in each study, it is not possible to draw standards of approach for burst fractures but only to suggest options based on it.

There is a lot of evidence suggesting that lesions with great amount of vertebral load sharing column damage associated with great compression of spinal canal poses high risk to neural structures, conditioning mechanical and neurological instability[2,3,6,7,9,12,14,19,22]. Burst fractures associated with equal to or greater than 50% of canal encroachment should be submitted to surgery in order to lower the neurological risk[15]. Patients with great amount of vertebral load sharing column damage, but less than 50% of canal compression, should be studied, according to Mehta et al., under erect radiography[13].

Our own policy is to elevate progressively the height of the bed, observing any kind of pain or neurological symptoms. In case of absence of symptoms and control of pain, when posed in a sitting position in bed, the patient is ready to the erect radiograph. This is a safe way to test the immediate stability of the fractures[13]. If the fractures have shown to be mechanically incompetent, with ulterior collapse or loss of height or even neurological symptoms, they should be operated on and, in the opposite case, treated by conservative means.

The operative approach is not considered without discordance. Siebenga suggests that the posterior approach has been sufficient to prevent neurological damage and to provide better results than the conservative treatment[15].

We could find only one trial comparing to the anterior or posterior approaches. Wood, Bohn, and Mehbod, in 2005, studied the differences in radiographic, clinical, or functional outcomes in a small number of individuals with stable burst fractures of the thoracolumbar junction, without any neurological deficit treated by a posterior fusion with instrumentation or anterior reconstruction. They concluded that although patient outcomes are similar, anterior fusion and instrumentation may present fewer complications or additional surgeries[21].

To our knowledge, this is the unique paper comparing to the two approaches in a prospective randomized fashion, but the results of only one paper are not sufficient to draw standards of treatments in such an important question. Due to the paucity of high quality papers available, these approaches were consi-

dered only options, until more information is available (Tables 3 and 4).

Table 3. New Surgical Approach Suggested

Neurologic Status	Posterior Ligamentous Complex	
	Intact	Disrupted
Intact	** Table 4	Posterior approach
Root injury	Posterior approach	Posterior approach
Incomplete SCI or cauda equine	Anterior approach	Combined approach
Complete SCI or cauda equina	Posterior (anterior)* approach	Posterior (combined)* approach

* Aggressive decompression in ASIA A patients is practiced in many institutions to optimize any potential for neurologic recovery, reconstruct the vertebral support column, restore CSF flow to prevent syringomyelia, and allow for short segment fixation.

Table 4. Intact Neurologic Status and Intact Posterior Ligamentous Complex

Canal encroachment		
<50%		>50%
Erect radiographs		Anterior or Posterior approach
Additional loss of vbh < 10% and no neurological symptoms	Additional loss of vbh > 10% or neurological symptoms	
Conservative	Anterior or posterior approach*	

Vbh: vertebral body height
* The decision for surgery after 10% reduction of vertebral body height is an approximation of the median values obtained by Mehta et al. and the approaches are suggested as options due to the small amount of prospective randomized trials published[13].

Conclusions

The thoracolumbar fractures, characterized by exclusive damage of vertebral body without distraction or rotational lesion of posterior ligament column, may pose enough risk to the conservative treatment if associated to large compression of spinal canal and great fragmentation of the load sharing abilities of the spine. Patients with canal compression equal to or greater than 50% of sagittal spinal canal diameter should be considered for surgery. Patients with lesser degrees of canal encroach may be submitted to erect radiographs and operated on if there is an additional loss of vertebral body height greater than ten per cent after erect radiography.

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