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Spinal Cord Injuries – When Is the Initial Tomography Insufficient?

Traumatismos raquimedulares – Quando a tomografia inicial é insuficiente?

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Abstract

Introduction Spinal cord injury (SCI) is common in polytrauma patients. The standard exam for the initial evaluation is computed tomography (CT), due to its higher sensitivity and specificity when compared with plain radiographs. However, CT is insufficient for the management of some cases, especially to evaluate ligamentous and spinal cord injuries. The objective of the present study is to describe clinical scenarios in which the CT scan was insufficient to guide the treatment of SCIs.

Methods We present the cases of four polytrauma patients with normal CT scans at admission and with unstable or surgically-treated lesions.

Discussion The cases reported evidence the need for ongoing neurological surveillance with serial physical examination and magnetic resonance imaging (MRI) in cases of neurological injury not explained by CT or occult instability.

Conclusion Computed tomography is not always sufficient to determine the management of SCIs. A comprehensive evaluation of the clinical data, CT findings and, occasionally, MRI findings is crucial in order to choose the best conduct.

Keywords
- spinal cord injury
- computed tomography
- polytrauma
- diagnosis

Resumo

Introdução O trauma raquimedular (TRM) é frequente no paciente politraumatizado. O exame padrão para avaliação inicial é a tomografia computadorizada (TC), dada a alta sensibilidade e especificidade quando comparada às radiografias simples da coluna. Entretanto, a TC é insuficiente em algumas situações, principalmente no diagnóstico de lesões ligamentares e medulares. O objetivo deste trabalho é mostrar situações em que a TC não foi suficiente para o diagnóstico das lesões medulares e o manejo dos pacientes com TRM.

Métodos Apresentamos quatro pacientes, vítimas de politraumatismo, com TC normal na admissão, e com lesões da coluna instáveis ou que necessitaram de tratamento cirúrgico.

Discussão Os casos em questão retratam a necessidade de vigilância neurológica contínua com exame físico seriado e realização de ressonância magnética (RM) em casos de lesão neurológica não explicada pela TC ou suspeita de instabilidade oculta.

Conclusão A TC nem sempre é suficiente para o manejo do TRM. A avaliação global dos dados clínicos, achados tomográficos e, eventualmente, da RM, é fundamental para escolher a melhor conduta.

Palavras-chave
- traumatismo raquimedular
- tomografia computadorizada
- politraumatismo
- diagnóstico

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Introduction

Between 13% and 30% of the patients who are victims of severe trauma present traumatic injuries in the spine, and about 1/3 of them will require surgical treatment of these fractures.[1–3]

The description of the scenario and the mechanism of trauma is fundamental in the initial care to raise the suspicion of lesions to the spine. Most of these lesions originate from automobile accidents and falls from great height,[4–6] and they are more commonly located in the thoracolumbar and cervical regions.[5,6]

After the initial stabilization of the patient, as recommended by the Advanced Trauma Life Support (ATLS) training program, pelvis, chest and cervical spine profile radiography exams are performed.[4,7] If there is suspicion of spinal trauma in other segments, radiological complementation is necessary.[4]

The difficulty in obtaining quality exams in simple radiographies of the cervicothoracic and craniocervical junction, especially in obese patients, as well as the difficulty to visualize disc-ligamentous and medullar lesions, resulted in the adoption of the computed tomography (CT) as the standard examination in the evaluation of spinal cord injuries (SCIs) in many trauma centers.[4,8,9]

The CT has a sensitivity higher than 98% for the diagnosis of spinal lesions (bone or disc-ligamentous), which is much higher than that of conventional radiographs. Additionally, it adds more information and details when the cuts are thinner (1–2 mm) and the images are reconstructed tridimensionally.[4] About 40% of fractures detected by CT are not observed with simple X-rays, or appear in an incomplete manner.[4,10,11]

On the contrary, magnetic resonance imaging (MRI) is not commonly used for the initial evaluation, given the fact that it is a longer, more cost-intensive examination, not available in most minor trauma centers, and with greater technical difficulties for its performance in polytrauma patients.[12]

In this context, the community of surgeons AOSpine recently published a new classification system for cervical, thoracolumbar and sacral fractures essentially based on the CT, which is an exam that is fast and widely available, characteristics that are paramount for the identification of spine instability and for therapeutic decision-making.[13]

Despite the high sensitivity of the CT to evaluate spinal lesions related to the polytrauma patient, in some situations, especially in cases of osteoligamentous or medullar lesions, performing the MRI is indispensable to understand the trauma and for therapeutic decision-making, as well as to avoid catastrophic neurological damage caused by occult instabilities.[13–15]

The objective of the present study is to report clinical cases in which the CT was insufficient for the diagnosis and therapeutic decision regarding patients with SCI.

Materials and Methods

We present a series of non-consecutive cases cared for by the main author (AFJ) and obtained from the spine surgery database of the teaching hospital of Universidade Estadual de Campinas. The database is approved by the Ethics and Research Committee of the institution.

The inclusion criteria were: patients who were victims of polytrauma with normal spinal CT or with apparently stable lesions, but who presented highly unstable lesions, or with neurological risk at admission or delayed.

Cases

1) A male patient, 27 years old, victim of a motorcycle accident, was admitted to the emergency room with Glasgow Coma Scale (GCS) score of 15, but with loss of sensitivity at level T6, paraplegic, and with hypotonic sphincter (Asia Impairment Scale [AIS] A). The total spinal CT at admission did not show evident alterations (►**Fig. 1A** – sagittal tomography at admission), and a

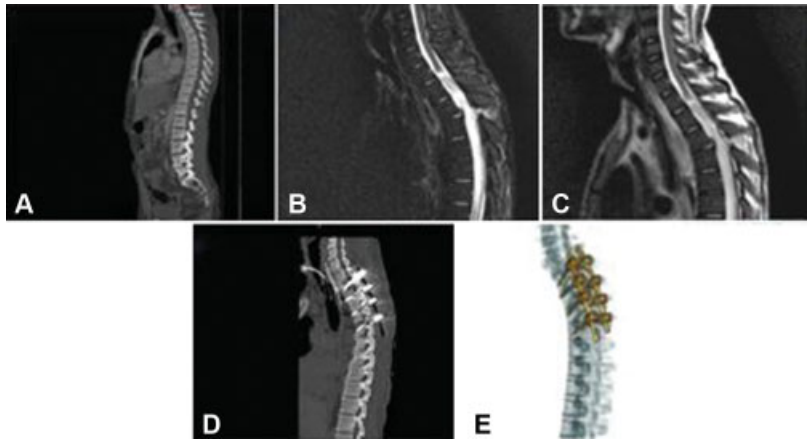

Fig. 1 (**A**) Computed tomography (CT) of the spine at admission, sagittal cut, without evident alterations related to trauma. (**B**) T2-weighted magnetic resonance imaging (MRI) sequence with fat suppression (short tau inversion recovery – STIR) showing small disc extrusion between T3 and T4, with change in medullary signal and ligamentous injury between posterior elements of T3 and T4. (**C**) The T2 sequence shows an interspinal ligament hypersignal, suggesting rupture, besides the spinal compressive effect extending from T1 to the medullary cone level. (**D**) Postoperative control CT of the arthrodesis with posterior instrumentation, fixating 4 levels (T2345). (**E**) Three-dimensional (3D) reconstruction showing the final aspect of the arthrodesis.

spinal MRI was performed, which evidenced a spinal cord signal alteration in the T2 sequence from level T1 to the medullary cone, with distraction between T3 and T4 (►**Figs. 1B** and **1C**). The patient was submitted to posterior arthrodesis (►**Figs. 1D** and **1E** – postoperative sagittal CT) between T23 and T45.

2) A female patient, 44 years old, victim of polytrauma with closed abdominal trauma, was admitted to the emergency section with GCS 15, without motor deficits. The lumbar spine CT at admission showed no evident alterations (►**Fig. 2A**). She was submitted to exploratory laparotomy with right hemicolectomy and segmental enterectomy that evolved with postoperative fistula, with no need for surgical retreatment, but requiring prolonged hospitalization for three weeks with the general surgery team. About four months after hospital discharge, in an outpatient return consultation, the condition evolved with deformity and lumbar pain. An MRI and a new spinal CT showed listhesis between L3 and L4 (►**Figs. 2B** and **2C**). The patient was submitted to posterior fixation through the route between L2 and L5, with total improvement of pain (►**Fig. 2A**).

3) A male patient, 36 years old, victim of a motorcycle accident, was admitted to the emergency department with GCS 15, tetraparesis (proximal grade III and distal grade II strengths in the right upper limb, proximal grade II and distal I strengths in the left upper limb, proximal grade II and distal grade I strengths in the lower right hand, and proximal grade III and distal grade II strengths in the left lower limb, compatible with centromedullary syndrome), hypoesthesia at level T6, and hypotonic sphincter (AIS C). The CT at admission did not show significant alterations in the spine (►**Fig. 3A**). The patient was maintained with rigid cervical collar and en bloc mobilization until the MRI, due to the presence of neurological deficit. After the MRI, an extensive spinal cord injury was found associated with a narrow cervical canal (►**Figs. 3B** and **3C**). Subsequently, the patient underwent cervical arthrodesis through the posterior route between C3 and C6, with spinal-cord decompression (►**Figs. 3D**, **3E** and **3F**), with significantly improved symptoms with 2 months of outpatient follow-up (AIS D).

4) A male patient, 25 years old, was admitted to the emergency department after being found on a public road with a history of motorcycle crash and ejected helmet. He evolved with cardiorespiratory arrest, requiring three cycles of resuscitation. He arrived intubated with GCS 3, cervical collar, isomyopic pupils, evident right tibial trauma, and hypovolemic shock. After the initial stabilization measures, he was submitted to skull (Marshall 2) and cervical spine CTs (►**Figs. 4A** and **4B**).

a. The patient was submitted to amputation of the right inferior limb (RIL), with good evolution due to the extent of the traumatic injury in his tibia. Off sedation,

Fig. 2 (**A**) Sagittal CT of the thoracolumbar spine without evident alterations related to trauma at admission. (**B**) CT of thoracolumbar spine performed ~ 4 months after the initial event, when the patient evolved with lumbar pain and deformity, showing listhesis of L3 over L4 with distancing of spinal processes. (**C**) MRI in a T2-weighted sequence showing listhesis of L3 over L4, posterior ligament injury, and cauda equina compression. (**D**) Postoperative control CT showing arthrodesis by the posterior pathway between L2 and L5.

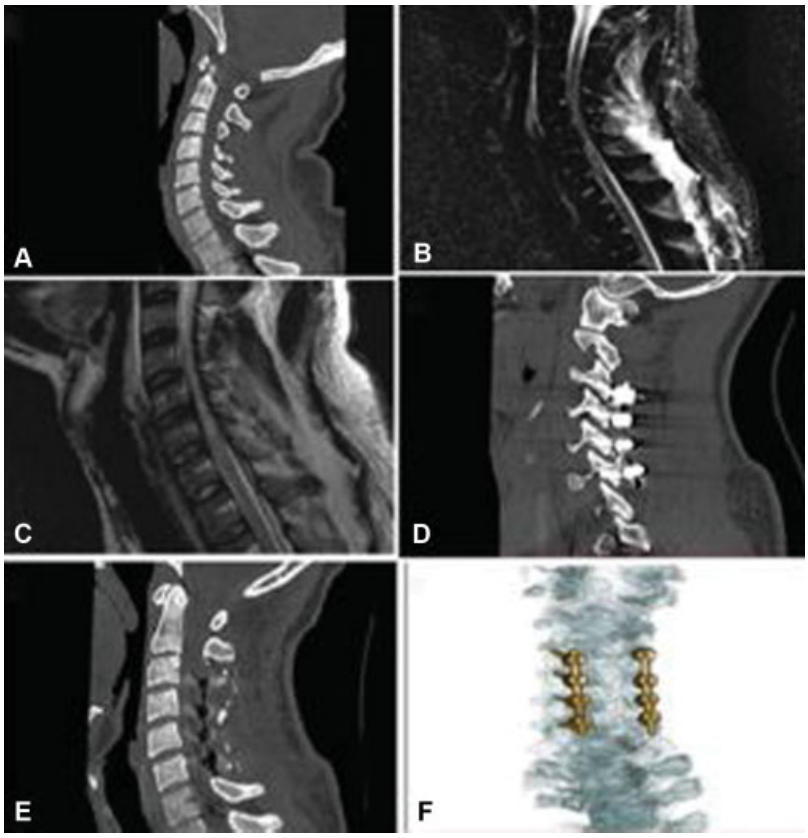

Fig. 3 (**A**) CT at admission, without evident alterations. (**B**) MRI in a T2-weighted sequence with fat suppression with extensive hypersignal in posterior elements of the cervical spine and hypersignal in the cervical medulla, with evident compression, without listhesis. (**C**) MRI in a T2-weighted sequence, showing traumatic myelopathy from C4 to C7, bulging of diffuse disc from C5 to C6, determining vertebral canal stenosis and edema area in the cervical and dorsal muscle-adipose planes. (**D and E**) Postoperative sagittal section CT with laminectomy and cervical arthrodesis by posterior route between C3 and C6. (**F**) CT with 3D reconstruction showing the final aspect of the arthrodesis.

he did not present motor deficits, and fully regained his consciousness. In ~ 30 days of hospitalization, he evolved with a vicious posture in the cervical region, and was submitted to a new CT of the cervical spine on the 34th day of hospitalization, which evidenced severe dislocation between C1 and C2 (►**Figs. 4C** and **4D**). The patient was submitted to posterior arthrodesis with complete improvement of posture, and evolved without neurological deficits (►**Figs. 4E**).

Discussion

In the present study, we discussed a series of cases of patients with severe polytrauma and SCI not adequately documented in the spinal CT at hospital admission. The cases in question reflect the importance of the need for constant neurological surveillance, with repetition of the physical examination and the performance of new imaging exams, such as the MRI, in cases of suspicion of instability or neurological injury not explained by the CT findings.

In a series with 188 polytrauma patients with cervical spine injury, in 37% of the cases the lateral incidence failed to provide the correct diagnosis, and the CT failed in 3 cases in which there were disco-ligamentous lesions.[4,11]

Nuñes et al,[16] who studied a group of 88 victims of severe polytrauma, comparing the helical tomography with simple radiographs for the diagnosis of cervical spine lesions, detected that 32 patients (36.4%) with cervical fracture were not diagnosed by X-ray, only by CT. The authors broadly advocate the use of CT to detect lesions in victims of severe polytrauma.[16]

Although the CT presents high sensitivity for the diagnosis of fractures, especially when compared with radiographs, it fails in cases of disco-ligamentous lesions, a situation in which the MRI has higher sensitivity.[15–17]

Pizones et al[18] prospectively evaluated 33 patients using simple radiography, and classified the lesions according to the system proposed by the AOSpine. Subsequently, these patients were submitted to MRIs. From 41 fractures diagnosed using CT and radiography, there was an increment of 9 additional lesions not revealed by the first 2 exams, totaling 50 fractures. In addition, the MRI detected 18 occult (disco-ligamentous) lesions, causing the classification of the lesions to change from A to B in 24% of the patients, and the therapeutic approach in 16% of the cases. The authors concluded that the MRI is fundamental for the treatment of thoracolumbar traumas.[18]

Based on this premise, Rihn et al[19] conducted a prospective study to evaluate MRI accuracy in the diagnosis of lesions of the posterior ligament complex (PLC) in victims of thoracolumbar trauma, compared with the intraoperative findings. The authors concluded that the MRI findings

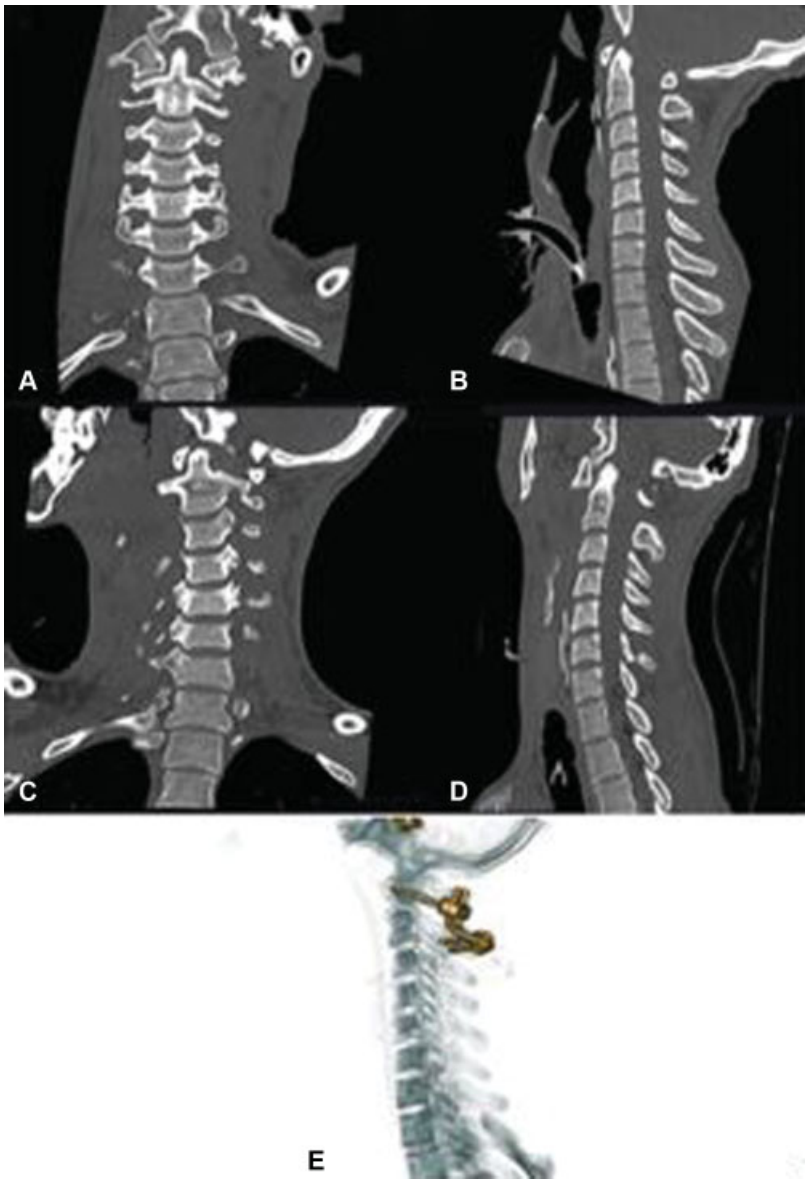

Fig. 4 (**A and B**) CT at admission, coronal and sagittal images respectively. Good cervical spine alignment and fracture of the C7 transverse process are noted. (**C and D**) CT of the 34the day of hospitalization, when the patient began to present a vicious cervical posture. There was a dislocation between C1 and C2 and an increase in the atlanto-dental interval in the sagittal section. (**E**) 3D CT for postoperative control after the patient underwent posterior cervical arthrodesis with lateral mass screws in C1 and lamina in C2.

showed a high negative predictive value, and sensitivity close to 100%; however, they had relatively low specificity, varying from 51.5% to 80.5%. Such relatively low sensitivity values and positive predictive value may result in greater surgical interventions in lesions that could once be treated conservatively. The authors conclude, therefore, that MRI findings cannot be used alone for the therapeutic decision.[19] Such evidence was corroborated by other studies.[14]

To establish a system of reproducible, simple and efficient classification, the AOSpine proposed a new model that, in addition to the criteria of morphology and lesion of ligament complex, also included facet lesion and the neurological status of the patient, which are fundamental conditions for the therapeutic decision-making regarding thoracolumbar and cervical fractures. Such conditions are evaluated by CT, because it is a fast and easy-to-access exam. However, many times, as we show in our sequence of cases, an MRI or a new CT is necessary to detect SCIs, disco-ligamentous lesions, and delayed instabilities.[13–15]

Regarding cervical spine trauma specifically, patients with GCS 15, without drug or narcotic effect, without neurological deficits, and who do not have pain on palpation of the cervical spine, may have the cervical collar removed without the need for complementary exams, a recommendation that has been proven by more than 20 clinical trials, which was also incorporated by the ATLS.[12,20] However, awake patients with pain or tenderness in the neck and normal CT may have the cervical collar removed as long as the radiograph in extension-flexion is adequate, or the MRI of the cervical spine does not show alterations.[21]

For patients who are symptomatic or who do not have a trustworthy exam, the primary scanning modality is the CT

from the occiput up to T1, with sagittal and coronal reconstruction. Simple radiographs do not add information, and, therefore, are unnecessary.[20] In the case of patients with normal cervical CT and coarse movements in the four limbs, and intubated patients, the cervical collar should be maintained until it is possible to perform a trustworthy clinical examination or an MRI.[21] However, some authors argue that the cervical collar of patients intubated but with cervical CT without alterations can be removed, since the incidence of ligament injuries in these cases is lower than 5%, with the incidence of significant lesions from the clinical point of view in less than 1% of the cases.[20]

Conclusion

Based on the cases reported and the literature review, we conclude that SCI is a multifaceted and complex disease. The serial neurological evaluation of the individual is necessary, as it complements the imaging exams.

The CT, which is an essential exam in the first care to the polytrauma patient, is not always sufficient for the management of SCIs at any level. The use of MRI is fundamental in some cases, especially when there is doubt between the conservative and surgical treatments. The combination of the clinical information, the tomographic classification and, eventually, the MRI data, are fundamental to choose the final conduct and to improve prognosis.

Conflict of Interests
The authors have no conflict of interests to declare.

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