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CASE REPORT

New concept of pathogenesis of impaired circulation in traumatic cervical spinal cord injury and its impact on disease severity: case series of four patients

M. Salkov¹ · V. Tsymbaliuk² · L. Dzyak³ · A. Rodinsky⁴ · Y. Cherednichenko⁵ · G. Titov⁶

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Abstract

Purpose The purpose of this study is to justify a new concept of the pathogenesis of secondary changes in the cervical spinal cord, and its correlation with the depth of development of neurological disorders in spinal injury.

Methods Standard magnetic resonance imaging examination and angiography of the cervical and vertebral arteries of four patients were performed to diagnose the prevalence rate of ischemia and edema, and examine the spinal cord vasculature. Correlation of the data obtained with the neurological status was performed.

Results Collateral circulation is most apparent in the upper-cervical region, above the C4 vertebra. Following occlusion of the vertebral artery, the circulation above the C4 vertebra is performed by collaterals of the ascending

cervical artery. With extensive damage to the spinal cord, the intensity of edema and ischemia can be regarded as the effect of damage to radicular medullary arteries, which are injured in the intervertebral foramen. Secondary changes of the spinal cord are most apparent by impaired circulation in the artery of cervical enlargement.

Conclusions Collateral circulation is a significant factor that limits the damage to the cervical spinal cord. Impaired circulation in the artery of cervical enlargement is significant in extension of perifocal ischemia. The appearance of early arteriovenous shunting in the region of a primary spinal cord injury (contusion focus) by angiography is pathognomonic. The data obtained open a perspective for the endovascular treatment of spinal cord injury.

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Keywords Spinal injury · Spinal circulation · Angiography · MRI examination

Introduction

According to previously published studies, the main factors in the pathogenesis of spinal cord injury are attributed to primary and secondary mechanism. Primary spinal cord injury occurs at the time of the initial trauma or damage, forming a zone of spinal cord contusion. Disorders can be found in the local vasculature, causing edema and hemorrhage. In the damaged area, paralysis of motor, sensory and autonomic neuronal functions can occur. Vascular dysfunction, ischemia, glutamatergic excitotoxicity, inflammation and apoptosis also develop in the perifocal zone [1–5].

In our opinion, one of the leading mechanisms in the formation of secondary injury and its extensiveness is vascular dysfunction, which occurs not in the area of the spinal cord injury, but in blood vessels supplying the spinal cord, i.e., in the branches of the vertebral, ascending, and deep cervical arteries.

Through a worldwide literature search, we did not identify one detailed clinical description of the features of impaired circulation in spinal injury. Based on the fundamental experimental studies of G. Lazort et al. on vascularization and hemodynamics of the spinal cord, we have conducted a clinical study of impaired circulation in the cervical spine and spinal cord as a result of injury, and we have defined the role of collateral circulation in this type of pathology [6–8]. Based on the results obtained, correlation of vascular disorders with the severity of spinal cord

ischemia and the severity of the patients has also been conducted.

Materials and methods

From May to August of 2014, we examined four patients with cervical spinal trauma. All patients were men, aged 20–62. We performed standard magnetic resonance imaging (MRI) of the affected spinal area and selective angiography of the cervical and vertebral arteries to determine the extent of damage to the medullary region, spinal cord compression, the prevalence rate of ischemia and edema, and vascularization of the spinal cord. The studies were conducted from day 1 to day 30 post-injury. Neurological impairment on the American Spinal Injury Association (ASIA) scale corresponded to A in two patients and D in remaining two patients.

Case reports

Case 1

We conducted a study of the collateral circulation of the vertebral arteries in a patient with spinal trauma, spinal cord injury, and dislocation fracture of C4–C5. The uniqueness of the study is in the visualization of collateral circulation following occlusion of both vertebral arteries. Clinically, the patient did not show any stem disorders with impaired vital functions, and vertebrobasilar insufficiency was not evident. Collateral

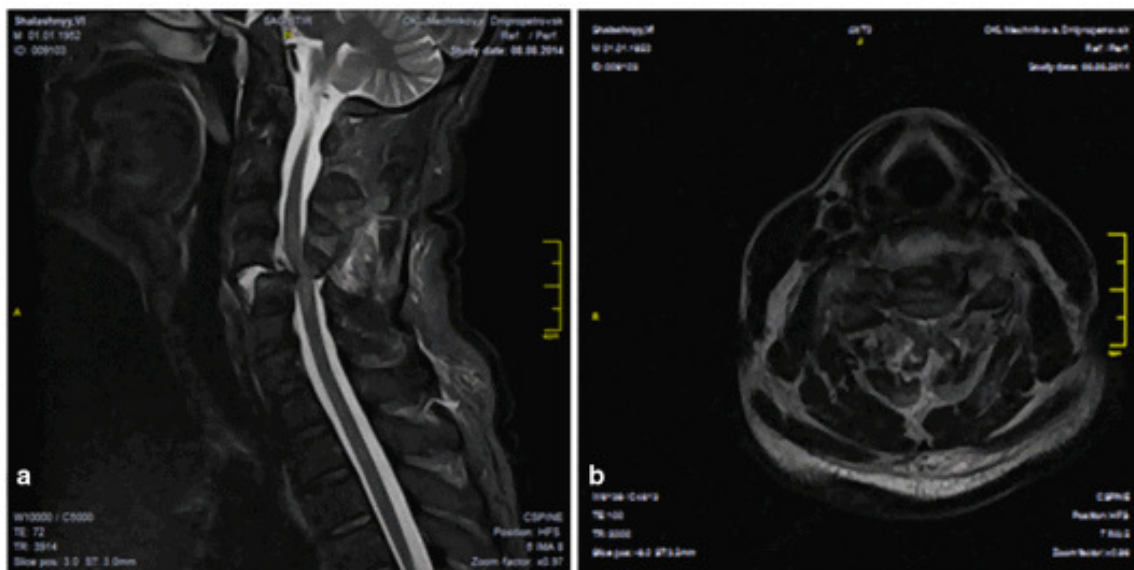


Fig. 1 Magnetic resonance imaging of Case 1. A dislocation fracture of C4–C5 can be observed, along with myelopathy at the level of C4–C5. **a** Sagittal view, **b** Axial view