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Revision surgery effectiveness in late thoracolumbar junction traumatic injury

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Traumatic injuries of the spine constitute a relatively small part of the consequences of the traumatic factor action on the human body but they significantly affect the social and economic component of the injured patients' life. During the Russian-Ukrainian war, the number of patients with traumatic injuries to the spine and spinal cord increased significantly. The analysis of previous armed conflicts shows that most spinal injuries in both military and civilians are closed. Therefore, the treatment strategy correspond to those in peacetime. One of the least studied issues is the feasibility of surgical decompression of the spinal canal in the late period of spinal cord injury.

An anamnestically complex case of traumatic injury of the thoracolumbar junction is presented. A patient with a combined injury underwent laminectomy of the Th12 vertebra and transpedicular fixation of the Th11, Th12, L1 and L2 vertebrae after fracture-dislocation of the Th12-L1, that was accompanied by gross neurological symptoms of ASIA A. Surgery was performed 11 days after the emergency hospitalization. 6 months after trauma it was revealed the screws malposition in the bodies of the Th12 and L1 vertebrae. After 10 months, a surgery was performed: removal of the left transpedicular screw from the body of the Th12 vertebra, laminectomy of the Th12, L1 and L2 vertebrae, an electronic neurostimulator was installed on the spinal cord, and 12 months after the injury, the transpedicular stabilization system was rearranged and the electrodes of neurostimulator were removed. Within 3 years and 7 months, after the appearance of acute pains in the area of the kidneys, an additional examination was performed. Fragmentation of the left rod of fusion system between the L1 and L2 vertebrae was revealed, as well as the presence of ossified fragments of the intervertebral disc at the Th12-L1 level, which caused absolute stenosis of the spinal canal. In Romodanov Neurosurgery Institute of National Academy of Medical Sciences of Ukraine, revision surgery was performed: adequate repositioning of the stabilization system and extensive decompression of the spinal canal with facetectomy and complete decompression of the dural sac. During the follow-up examination after 4 months, regression of the neurological deficit from ASIA A to ASIA B was recorded.

In the article classic errors during surgery of traumatic injuries of the thoracolumbar junction and the expediency of performing decompressive-revision surgical interventions in the late period of spinal cord injury were analyzed.

Keywords: *traumatic injuries of the spine; thoracolumbar junction; revision surgery; chronic spinal cord injury*

Introduction

Although the proportion of traumatic spine injuries among the consequences of the action of a traumatic factor on the human body is relatively small, their impact on the social and economic component of the patients' lives is much greater compared to other injuries [1]. Analysis of fracture incidence depending on the level of damage has revealed that the most vulnerable is the thoracolumbar junction (TLJ) zone [2], which includes the two lower (according to some authors, three) thoracic vertebrae and two upper lumbar vertebrae. This zone is characterized by specific biomechanics due to the junction of the rigid thoracic spine into a relatively mobile

lumbar spine. According to some epidemiological studies, about 60% of cases of spinal fractures occur in the TLJ zone [3]. For example, according to P. Leucht et al. [4], the Th11-L2 vertebral zone was damaged in 58.4% of cases (Th11 - in 3.7%, Th12 - in 14.1%, L1 - in 28.5%, L2 - in 12.1%). It has also been noted that the Th12 and L1 vertebrae account for about 48% of burst fractures of the spine [5].

If we consider spinal cord injury as a complex of pathomorphological changes of various anatomical structures, the neurological deficit caused by injury to the neural structures of the spinal canal has the greatest impact on the quality of life of the injured person.

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Since the spinal canal has the largest diameter in the lower lumbar region of the spine, and the roots of the lumbosacral nerves are much more mobile than the medullary cone, the incidence of neurological injuries accompanying L3–L5 vertebral fractures is usually lower than that for fractures of the vertebrae located above [6], whereas injuries of the upper thoracic and mid-thoracic regions are most often accompanied by severe neurological disorders, and depending on the nature and extent of injury, patients in most cases register either ASIA A or ASIA D–E [7]. The TLJ zone is characterized by a full spectrum of the degree of damage to neural structures (from ASIA A to ASIA E). According to the data of various studies, the frequency of damage degrees varies significantly, but in otherwise identical conditions of damage, TLJ is more "favorable" for the regression of neurological disorders compared to the Th1–Th10 zone [8–13]. The specified features determine "more aggressive" surgical approach, aimed at improving the quality of life of the injured as much as possible.

On the background of the Russian Federation's military aggression against Ukraine, the issue of treatment strategy for closed injuries to the spine and, in particular, to the TLJ zone is relevant. Usually, combat-related spinal injury is considered primarily as a gunshot injury (bullet or shrapnel) with or without damage to neural structures and, therefore, a neurological deficit. Such injuries are often quite easy to diagnose due to the presence of skin damage (entry wound). Extraneous bodies that have actually or probably affected the structures of the spinal column are well visualized radiologically [14]. Data on spinal cord injuries among US military personnel during Operation Iraqi Freedom (2003–2010) and Operation Enduring Freedom (2001–2013) demonstrate that the majority of injuries (66–71%) are closed, and their treatment strategy are consistent with those in peacetime [15, 16]. Thus, J.A. Blair et al. note that 56% of spine injuries were caused by explosions, but only 32% of them were due to the direct impact of debris, 29% - during transportation, 15% were caused by gunshot injuries [17]. In servicemen with severe neurological deficits, spinal cord injuries due to penetrating wounds has been reported in less than 50% of cases. Although spinal cord injury during military operations as a whole account for only 5% of all injuries, they are the second most frequent cause of disability [18].

In modern warfare, the vast majority of both civilians and military casualties are polytrauma patients. Therefore, medical care is provided in compliance with the principles of "damage control", according to which spinal surgeries are not life-saving and may be delayed. Most often, the severity of the injured person's condition, the stage of evacuation and the lack of an adequate specialist expertise are the reasons for performing surgical correction several weeks after injury, and the scope of intervention is not always optimal.

Current approaches to the treatment of injured patients with closed spinal cord injury consider performing surgical correction 72 h after the injury as "late surgery" and associate it with a worse prognosis

for the regression of neurological disorders [19]. In this case, the principle "better late than never" is actually proposed, but the limits of this "late" are not defined [20]. In Ukraine, there are not isolated cases when patients do not undergo decompression of the spinal canal in the late period of spinal cord injury due to the absence, in the opinion of surgeons, of a positive neurological outcome. Such strategy can also be observed for technically incorrectly installed stabilization systems (predominantly transpedicular fixators), if defects are detected 6 months or more after the surgical intervention. A review of the specialized literature of recent decades revealed no studies convincingly determining the optimal treatment strategy for these patients.

A feature of foreign publications on surgical problems, particularly those devoted to spine surgery, is a more free discussion of errors and complications compared to domestic scientific works [21–24]. However, a number of critical points remain unexplained. For example, it is known that 17–25% of traumatic injuries of the TLJ are initially undiagnosed, but cases of prolonged untreated spinal cord compression have not been described. It is also known that transpedicular screw placement defects with perforation into the spinal canal are always recorded, the frequency of which depends on the level of stabilization [25,26]. However, cases of prolonged absence of correction of such defects are usually not specified.

The specified features leave open the question of the feasibility of performing decompressive and stabilizing interventions in patients with long-standing compression of spinal canal structures caused by a traumatic compression factor (bone fragments, intervertebral disc fragments, hematoma, etc.) or iatrogenic (transpedicular screw) genesis. Previously, a clinical case of positive neurological symptoms was described in a patient with severe traumatic spondyloptosis of the TLJ during surgical correction 3 months after the injury [27]. An anamnesticly more complicated situation is presented.

Clinical case

A 26-year-old patient M. was injured under unspecified circumstances. On admission to a healthcare facility at the place of residence, he was diagnosed with: closed vertebral and spinal cord injury, locked fracture-dislocation of the Th12 and L1 vertebrae, severe spinal cord contusion, closed craniocerebral injury, cerebral contusion II (**Fig. 1**).

11 days after the injury, a surgery was performed: laminectomy of the Th12 vertebra and transpedicular stabilization of the Th11, Th12, L1 and L2 vertebrae (**Fig. 2**). No positive dynamics were recorded on discharge from the hospital.

Magnetic resonance imaging was performed 6 months after the patient underwent rehabilitation therapy. The screws malposition in the bodies of the Th12 and L1 vertebrae, as well as the presence of a large fragment that compressed the spinal cord (**Fig. 3**), was revealed.

The patient underwent surgery 10 months after injury: removal of the left transpedicular screw from the

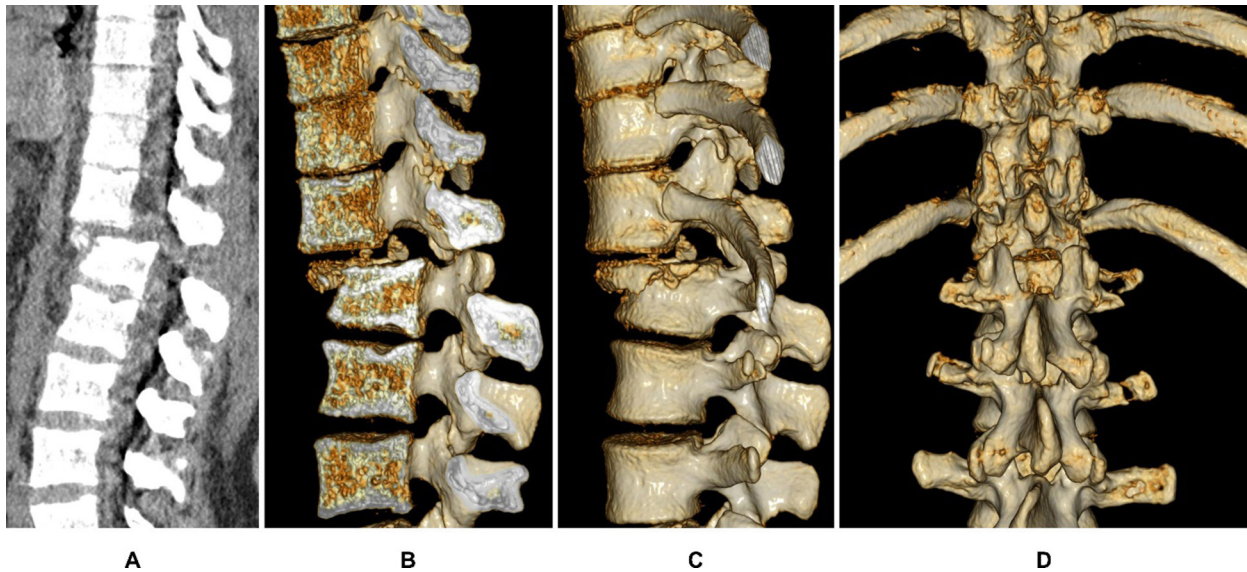


Fig. 1. Computed tomography of the thoracolumbar junction zone during the patient's initial hospitalization: A - sagittal reconstruction. Three-dimensional reconstruction: B - section in the mid-sagittal plane; C - left side view; D - posterior view

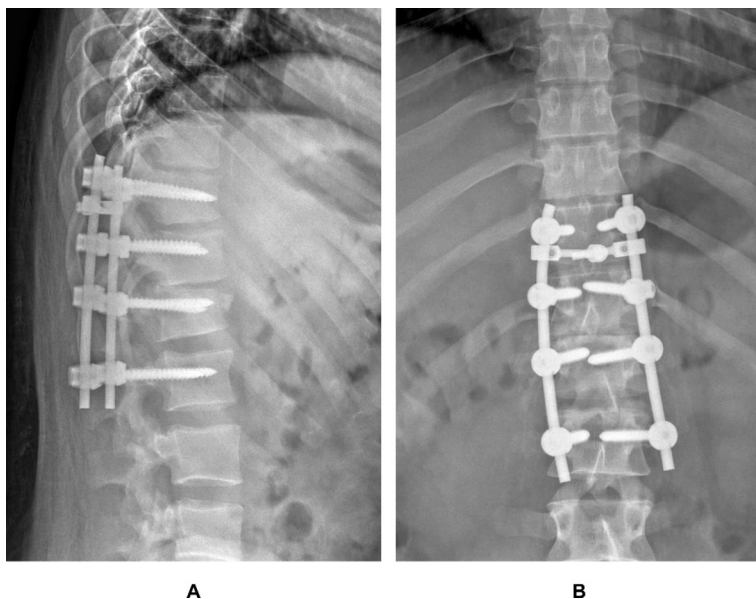


Fig. 2. X-ray 23 days after the injury: A - lateral projection; B - anteroposterior projection

body of the Th12 vertebra, laminectomy of the Th12, L1 and L2 vertebrae, and the installation of an electronic neurostimulator on the spinal cord. The transpedicular stabilization system was repositioned and the electrodes of the electroneurostimulator were removed 12 months after injury.

For 3,5 years after injury, the patient regularly underwent rehabilitation courses, which had no clinically significant effect. After 3 years and 7 months, the patient noted sharp pains in the lumbar region in the area of the surgical intervention. The follow-up examination revealed fragmentation of the left rod of the stabilization system between the L1 and L2 vertebrae, as well as the presence of ossified fragments of the intervertebral disc at the Th12-L1 level, which resulted in absolute stenosis of the spinal canal (**Fig. 4**).

After repeated refusals to perform surgical correction, the patient went to the Institute of Neurosurgery named after A.P. Romodanov, Ukraine.

Neurological status at the time of hospitalization: no pathology detected on the part of the cranial nerves. Strength in the upper limbs - 5 points, lower paraplegia, total anesthesia from the Th11-Th12 level. Tendon and periosteal reflexes from the upper limbs are brisk, symmetrical, from the lower limbs are absent. Local soreness in the postoperative scar area with minimal rotational movements is evident.

Surgical intervention was performed: removal of the connecting beams of the stabilization system, removal of the transpedicular screw from the body of the Th12 vertebra on the right and screws from the body of the L1 vertebra, extended laminectomy of the Th12

and L1 vertebrae with medial and lateral facetectomy, meningeolysis and radiculolysis of the specified area, removal of ventral compression of the dural sac, repositioning transpedicular screws into the bodies of Th12 and L1 vertebrae with installation of beams and two transverse ties (**Fig. 5**).

In the postoperative period, spiral computed tomography was performed twice: 2 days and 3 weeks after the surgical intervention, when the patient was already in a sitting position (**Fig. 6**).

No convincing signs of a change in the level of neurological disorders were observed during the period of stay in the hospital, but the nature of pain sensations changed and became neuropathic in nature. The follow-up examination 4 months later showed the regression of neurological disorders to ASIA B. The pain syndrome has almost completely regressed.

In the given clinical case, two aspects that are of fundamental importance in the treatment of patients with traumatic injuries of the TLJ zone are worthy of attention. First, in our opinion, a number of "classic" mistakes were made during the treatment, the analysis of which makes it possible to identify the most critical points of providing assistance to the injured. Secondly, the obtained positive neurological dynamics gives reason to assert the expediency of reconstructive revision surgical interventions even in the long-term period of the injury.

In order to organize the errors in providing assistance to the injured, we have suggested dividing them into the following categories: strategic, tactical, and technical. Mistaken strategy is initially characterized by an incorrect overall focus of assistance. For instance, choosing a conservative method of treatment in the presence of indications for surgical correction. The

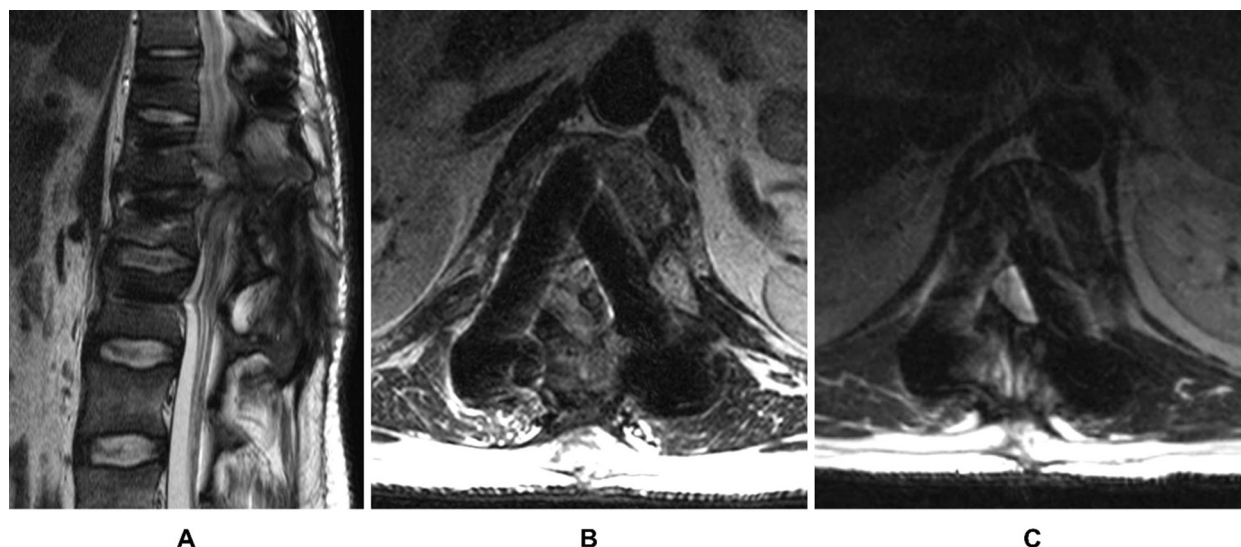


Fig. 3. Magnetic resonance imaging (6 months after injury): A – mid-sagittal section; B – section at the level of the Th12 vertebra; C – section at the level of the L1 vertebra

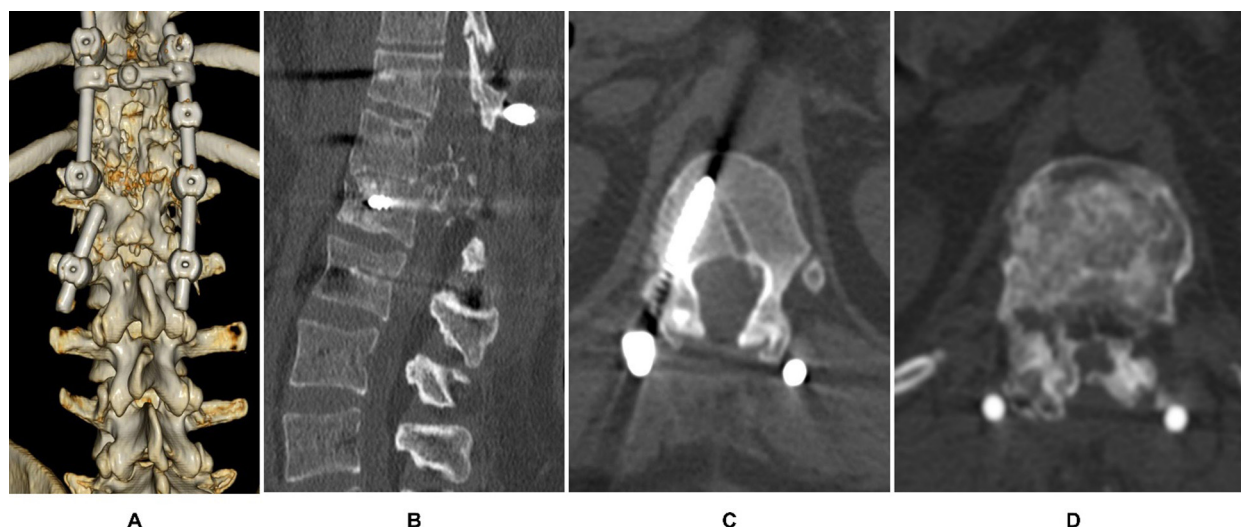


Fig. 4. Computed tomography 3 years and 7 months after injury: A - three-dimensional reconstruction, posterior view; B – sagittal reconstruction; C – section at the level of the Th12 vertebra; D – section at the level of the Th12-L1 intervertebral disc

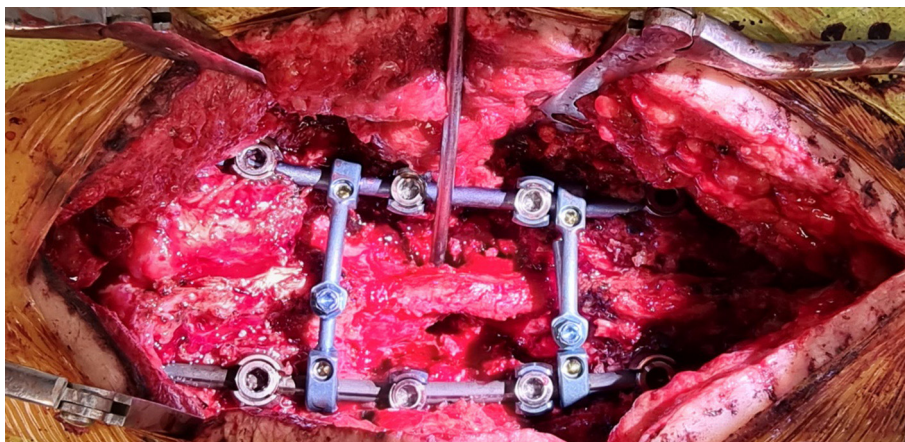


Fig. 5. Intraoperatively after performing the main surgical steps. The cannula of the aspirator is located under the dural sac at the level of the Th12-L1 intervertebral disc

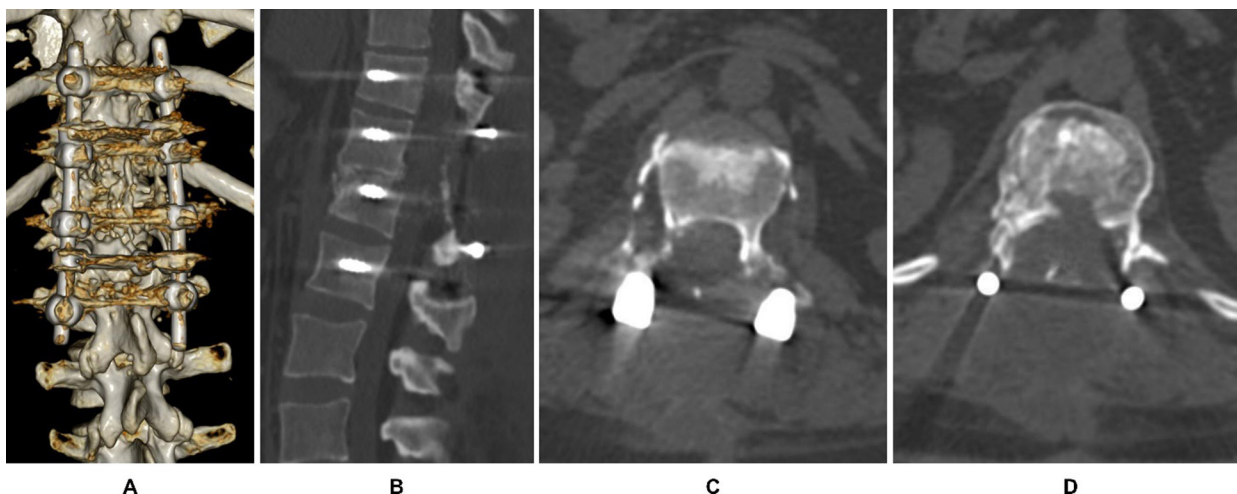


Fig. 6. Computed tomography 3 weeks after revision surgery: A – three-dimensional reconstruction, posterior view; B – sagittal reconstruction; C – section at the level of the Th12 vertebra (above the entry of the screws into the body); D – section at the level of the intervertebral disc Th12-L1

unreasonably long preoperative period, which is certainly important for the regression of neurological disorders in patients with compression phenomena of spinal canal structures can be included in this category. Tactical errors include incorrect choice of the optimal method of surgical intervention, which does not take into account the entire complex of clinical and pathomorphological changes present in the patient. This category includes the choice of surgical approach, the volume resection of bony structures, the completeness of decompression, the method and extent of stabilization, etc. Of course, the specified components, despite the presence of more or less detailed recommendations for providing assistance to the injured, are actually determined by the doctor, who at the time of the surgical intervention is guided by certain clinical arguments. Only a retrospective analysis of the outcome of the performed operation can assess the correctness of the choice, which in the long term will optimize the algorithm for choosing tactics. Technical errors are defects in the surgical intervention of a

pre-planned extent, for example, incorrect installation of pedicle screws, damage to the dura mater, etc.

In this case there are some of the defects above-mentioned. Obviously, the significant duration of the preoperative stage may be due to the severity of the patient's condition and other factors and cannot be unequivocally assessed without a detailed review of all medical records. The volume of decompression performed is probably insufficient (see **Fig. 4B**). The concept of spinal canal decompression for traumatic spinal cord injury is not clearly regulated. There are no clear guidelines regarding its length (number of arches that are resected) and width. When performing decompression, the surgeon has to solve several tasks: to eliminate compression of the structures of the spinal canal, and perform revision of the epidural space to identify compression factors that were not visualized during preoperative examinations or occurred directly during surgery. Some authors have pointed out that failure to consider the intervertebral disc condition of the

injured spinal motion segment is one of the reasons for revision surgery in case of traumatic spinal cord injury. This is especially important in AO Spine classification Type C injury, when repositioning of displaced vertebrae may involve the prolapse of the traumatically injured intervertebral disc into the spinal canal.

As mentioned above, transpedicular screw placement defect is not a unique situation. Thus, according to M. Kreinest et al., on average, every 5th installed screw goes beyond the the arch pedicle (21.8% – with open installation, 15.2% – with minimally invasive) [28]. The defect is most often registered at the level of Th12 and L1 vertebrae, as well as Th7 and Th8 vertebrae. Lateral deviation is twice as common as medial deviation. However, damage to the medial wall of the arch pedicle with the entry of the screw into the spinal canal, if detected and repaired in time is not catastrophic in most cases. Since the expediency of postoperative follow-up with the use of computed tomography remains debatable, the main signs that give reason to suspect the intracanal screw location are the appearance or increase of neurological impairment and/or violation of the Lenke criteria [29–31]. In this case, the assessment of neurological deficit could not indicate technical defects due to the baseline ASIA A level, however, a violation of the 3rd Lenke criterion (Th12 and L1 vertebral bodies) was noted, which could be the reason for performing postoperative spiral CT scanning (see **Fig. 2B**).

The feasibility of surgical decompression in the long-term period of spinal cord injury remains an open question. All publications on this topic that we have identified date mainly from the 1970s and 1980s [32, 33]. This trend is more indicative of improved quality of care for the injured through the development of medicine in general, since no works demonstrating the inexpediency of such interventions have been revealed. Obviously, the result obtained by us is an isolated one, and the regression of the neurological deficit is not so distinct, but even a slight improvement of functions is often a significant achievement for this category of patients and their relatives. Informing the patients about the possibility of performing surgery in the long-term period of injury, as well as collecting and systematizing the results, will help to optimize the treatment strategy for patients and improve their quality of life.

Analysis of the data presented gives grounds for the following conclusions:

1. Performing extensive decompression of the spinal canal in patients with traumatic thoracolumbar spine injury allows not only eliminating spinal cord compression but also performing the necessary revision measures.

2. Monitoring the placement of transpedicular screws using computed tomography may be appropriate at least in those cases when the assessment of the neurological status is not informative.

3. Decompressive-revision surgical interventions in the long-term period of spinal cord injury should be considered appropriate, since their performance may have a positive neurological outcome.

Information disclosure

Conflict of interest

The authors declare no conflict of interest.

Informed consent

Informed consent was obtained from the patient.

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