SURGICAL TREATMENT OF A MINE BLAST WOUND OF THE T11 VERTEBRA WITH ANATOMICAL DISRUPTION OF THE SPINAL CORD: A RARE CLINICAL CASE AND A BRIEF REVIEW OF THE CURRENT LITERATURE

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The experience of treating a patient with a mine blast wound of the T11 vertebra with an anatomical disruption of the spinal cord, bilateral hemo- and pneumothorax is presented. As a result of the injury, the patient suffered massive destruction of soft tissues with the formation of a full-thickness defect up to the vertebral bodies. The tactics of staged surgical treatment of the patient are described: elimination of fracture dislocation, fixation of the spine and plastic surgery of the soft tissues of the wound defect using the VAC system.
A review of current publications devoted to the epidemiology and tactics of treatment of combat injuries of the spine and spinal cord is presented.

Key Words: combat spine injury, combat spinal cord injury, treatment of combat spine injury, combat injury, spinal gunshot wounds, VAC system, VAC bandage.

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Patient P., 26 years old, suffered a mine blast wound. He was taken to the local central regional hospital, where the patient was diagnosed with a gunshot shrapnel blunt wound to thoracic spine, a gunshot fracture dislocation of the T11 vertebra with a complete anatomical disruption of the spinal cord and a right-sided hemothorax.

Initial surgical wound debridement (entrance wound) of the lumbar spine and the insertion of the chest tube (Bülau drain) were performed. The patient was airlifted to the neurosurgical center.

Upon admission, the patient complained of pain in the thoracic and lumbar spine, loss of movement and sensitivity in the legs.

The severity of the injury and condition was assessed: 26 points according to ISS, 17 points according to the Scale of the Field Surgery for Condition on Admission (FS-CA) (moderate severity).

Neurological status according to the ASIA scale: Grade A – a complete functional and anatomical disruption from the level of T11 vertebra and pelvic organ dysfunction accompanied by urinary retention.

Examination of the wound site: entrance wound of irregular shape up to 12 cm in diameter along the midline in the lumbar spine. The wound is contaminated with fragments of dress. The spine was a wound bed. Bloody issue and cerebrospinal fluid discharged from the wound (Fig. 1).

The patient underwent a panoramic computed tomography scanning. A fracture dislocation of the T11 vertebra and bilateral hemo- and pneumothorax have been detected (Fig. 2). Emphysema with the air spreading via the aponeurotic spaces of the back muscles to the cervical spine attracted attention.

Diagnosis: mine blast wound; open concomitant penetrating thoracic spinal cord injury; shrapnel blunt penetrating wound of the thoracolumbar spine with unstable gunshot complete anterolateral fracture dislocation of the T11 vertebra; anatomical disruption of the spinal cord; lower paraplegia; anesthesia from the T11 level; pelvic organ dysfunction; external cerebrospinal fluid leakage; bilateral hemo- and pneumothorax; traumatic pneumonia; wound of soft tissues (entrance wound in the lumbar spine). Surgery: insertion of the chest tube to the right pleural cavity (removed on day 5); a bedsore of the gluteal region.

After examination and preoperative assessment and planning (day 2 from the moment of injury, day 1 from the moment of admission), the patient underwent initial surgical debridement, reduction of fracture dislocation, dural plasty and posterior internal transpedicular fixation of T9–T10–T11–L2–L3–L4 vertebrae (Fig. 3).

After the removal of the foreign body the wound bed was the posterior surface of the T11 and T12 vertebral bodies. The

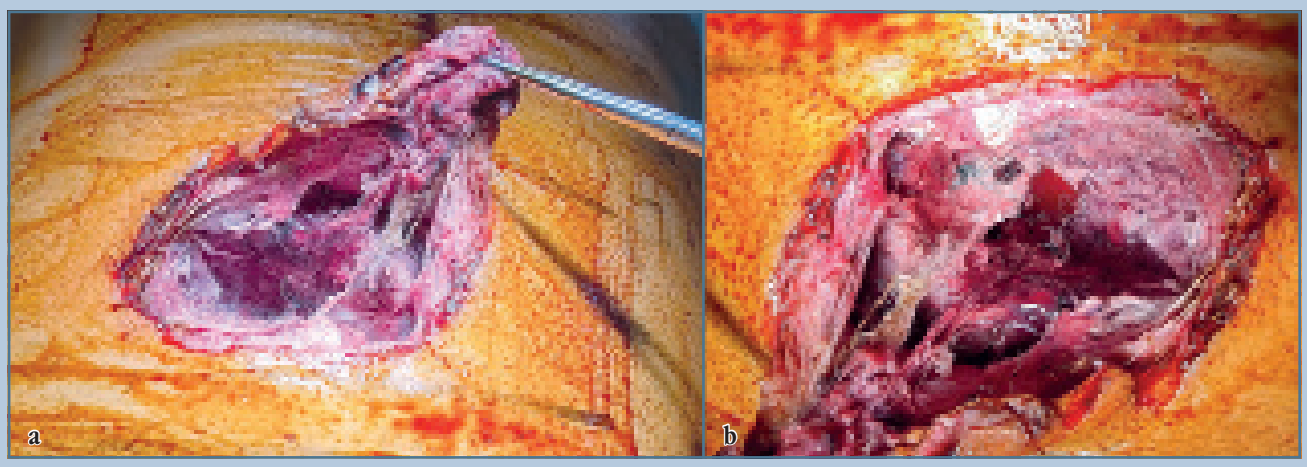

Fig 1
The wound side of a patient P., 26 years old: **a** – general view of the lumbar spine after skin treatment; **b** – view of the inlet

total absence of the dura mater in the surgical site and the detachment of soft tissues from the bone surface were the unique characteristics of this injury. An attempt to expand the bone window by laminectomy and identify the edge of the dura mater was unsuccessful. The defect spread significantly above the injury level. The injured edge of the dura mater was displaced cephalad and caudad by more than a segment. Only areas of the spinal cord and root injury were visualized. Therefore, the spinal canal was sealed with a fragment of the aponeurosis. The fixation of the latter was complicated due to the complete detachment of soft tissues (ligaments, tendons, periosteum) from the vertebral surface. The surface of the bone, including the posterior surface of the vertebral bodies, arches and facet joints did not have any soft tissues on them. The flap was fixed with fragments of titanium plates for cranioplasty to the vertebrae and fusion of bone. Tightness has been achieved.

Fracture dislocations were partially set. Pedicle screw placement was performed in the T9–T10–T11–L2–L3–L4 vertebrae and rigid fixation was achieved.

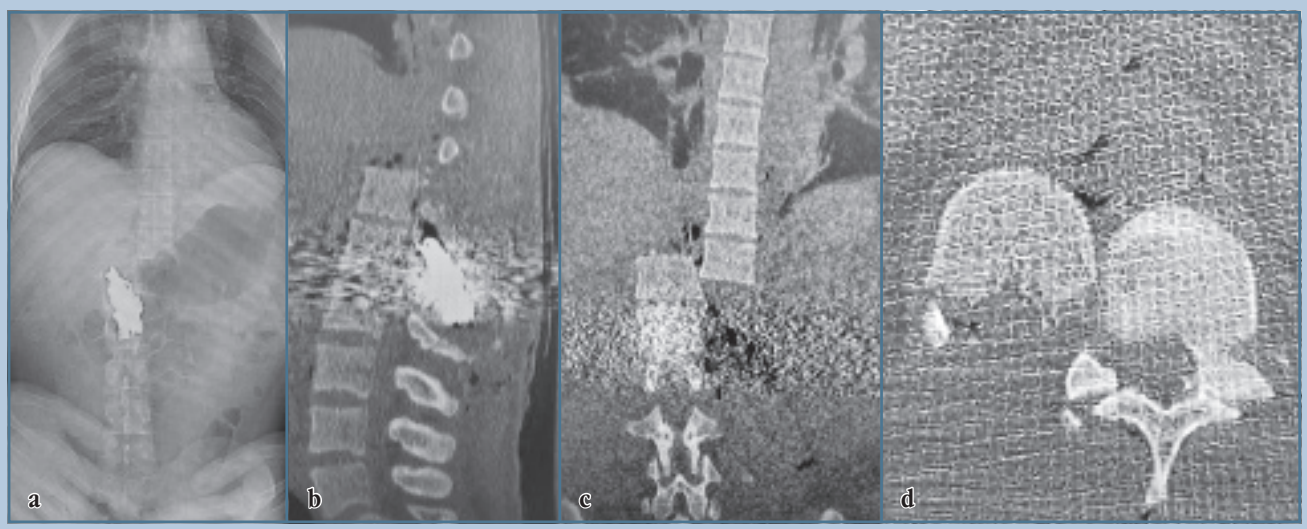

Fig 2
CT scan of the thoracic and lumbar spine of wounded patient P., 26 years old: **a** – topogram; **b** – sagittal reconstruction; **c** – frontal reconstruction; **d** – axial section at the level of fracture dislocation

A high likelihood of infectious complications was assumed due to external contamination and a large number of necrotic and injured tissues in the projection of the surgical wound. The situation was worsened by the presence of a skin and soft tissue defect in the entrance wound area, with a volume exceeding 200 cm^3, which reconstruction using local tissues was unfeasible. It was decided to perform a staged wound debridement using a vacuum drainage system (VAC system) and subsequent complete closure of the wound (Fig. 4).

The VAC system has been operated for 10 days. Three sponge replacements were performed. The wound was treated with antiseptic solutions during dressings. After debridement, the second stage of the surgery was performed: reduction of residual subluxation, transpedicular fixation of T9–T10–T11–T12–L1–L2–L3–L4 vertebrae and plasty of a soft tissue defect (Fig. 5).

Due to the approximation of the wound edges after the VAC system, it was possible to perform plastic surgery with local tissues. Nevertheless, there was a cavity remaining in the area of the entrance of the injuring projectile for insertion an active suction drain for one day. The wound healed by primary intention.

The patient was treated with the broad-spectrum antibiotics from the moment of admission. Wound fluid culture was performed, and according to the results, no pathogen was detected. But 18 days after admission, *Acinetobacter baumannii* was detected in the wound fluid. The therapy was corrected in accordance with the data on the antibiotic susceptibility pattern. On the day of the removal of the VAC system, the cultures were pathogen-free.

Post-traumatic pneumonia was resolved on the background of non-surgical therapy. Urinary tract antiseptics were used to treat urinary infection in accordance with the standard procedure.

The patient was verticalized two days after surgery. 3 weeks after, he was transferred to a rehabilitation in-patient clinic. At the time of discharge, the patient sat down in bed without assistance and moved in a wheelchair. The pain level decreased from 7 to 2 points according to the VAS. Neurological status: lower spastic paraplegia and anesthesia from the T11 level; pelvic organ dysfunction accompanied by urinary retention. The patient was transferred to intermittent catheterization. The patient's condition was evaluated according to the hospital anxiety and depression scale (HADS) upon admission and discharge from the hospital (3 weeks after); a decrease in the level of anxiety from 12 to 8 points and depression from 12 to 9 points was recorded.

A positive change in the healing of a bedsore on the sacrum as well as the active granulation tissue formation were noted upon discharge.

Additionally, there was a 1 point reduction in the intensity of anxiety or depression according to the findings of testing on the EuroQol Group scale (EQ-5DTM). The overall subjective assessment of the quality of life improved from 20 to 45 points (maximum – 100).

Discussion

Gunshot wounds to the spine and spinal cord often result in long-term disability or even mortality. In the case of penetrating wounds, the outcome depends on the type of injuring projectile (bullet, splinters, etc.), the speed of its movement, the number of penetrating particles, and, of course, the nature of caused injuries. According to a recent review of published data on combat spine injuries, the lumbar spine is most frequently injured (44 % of cases), followed by the thoracic spine (33 % of cases) and the cervical spine (23 % of cases) [1]. In the historical context, most of these cases were bullet wounds. As for the present, mine blast wounds have become more relevant. Bullet wounds to the head, neck, back and spinal cord account for only 10–21 % of mine blast wounds [2].

The most common types of spinal fractures with this type of injury are compression and explosive fractures and fracture of the transverse processes of a vertebra (32.0 %, 30.5 % and 24.0 %,

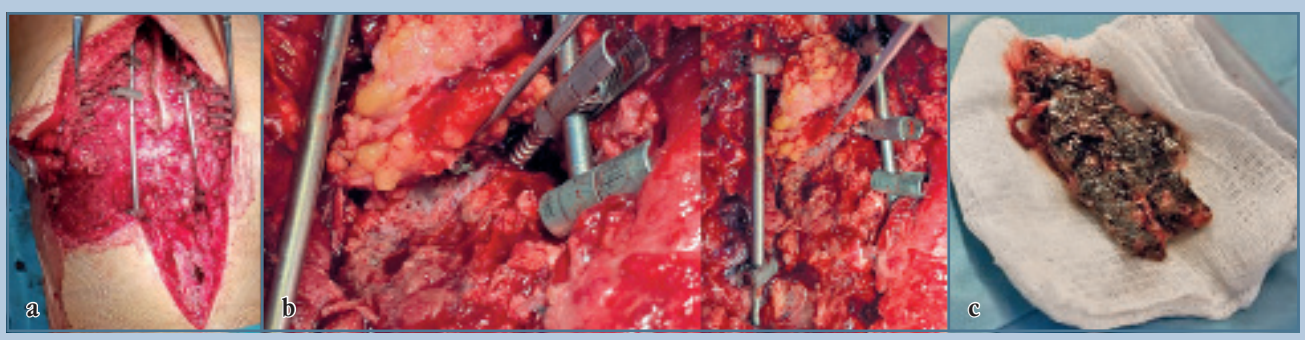

Fig 3
Intraoperative images of patient P., 26 years old: **a** – general view of the wound; **b** – posterior surface of the vertebral body, a fragment of the aponeurosis, fixed with titanium mesh; **c** – foreign body

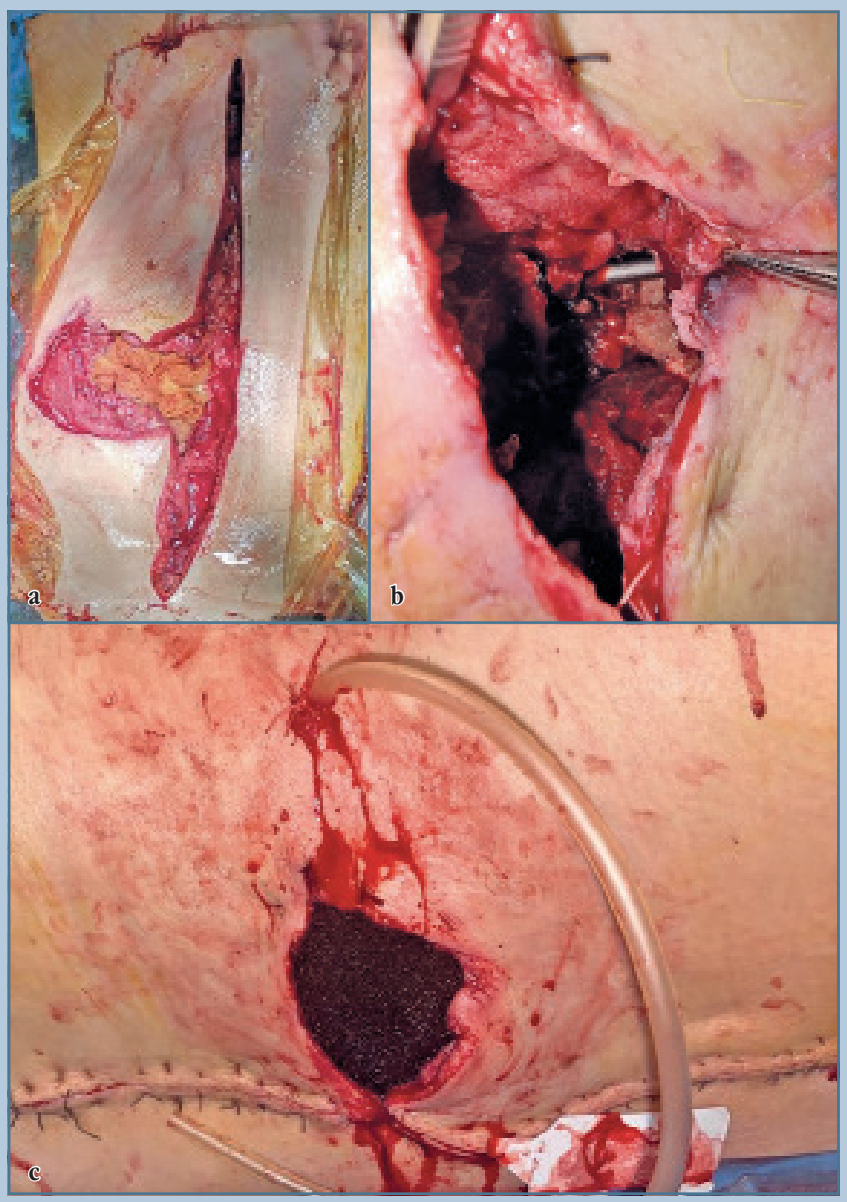

Fig 4
Intraoperative view of the wound of patient P., 26 years old: **a** – before suturing; **b** – area of tissue defect, metal structure at the wound bed; **c** – the VAC system sponge (visit the journal's website for video for Fig. 4)

respectively) [1]. Since combat spinal injuries are often mixed with other trauma and injuries, there are no standard treatment guidelines for them. The decision is made individually in each case.

In the case of wounds with high-velocity projectile, a careful debridement is required due to the likely formation of an extensive infected wound cavity as well as the presence of fragments and splinters inside the wound [3]. The absolute indication for surgery is the progressive loss of neurologic functions, especially if the compression of nervous tissues is confirmed [4]. Meanwhile, it should be considered that the probability of surgical complications outweighs that of non-surgical treatment (20 % and 7 %, respectively) [5]. The presence of a foreign body (fragments and splinters of the strike element) and the possibility of its migration are an absolute indication for its earlier removal, especially in case of incomplete spinal cord injury or the progression of neurological disorders. In case of complete anatomical disruption of the spinal cord, the removal of foreign bodies does not result in the recovery of neurological functions [6]. Cerebrospinal fluid leakage is another indication for surgery. In this case the surgery should include a direct reconstitution of the dural sac integrity. It is possible to use fibrin glue in combination with an artificial or local (fragment of aponeurosis) autograft [1].

The most common postoperative complications of combat spinal cord injuries include wound infections, venous thrombosis and cerebrospinal fluid leakage [7].

Schneider et al. [8] described a series of patients (46 US soldiers) who had suffered explosive penetrating wounds to the spine during the World War II. Laminectomy was used as a treatment technique (in the presence of progressive neurological disorders or fragments of strike elements or bones in the vertebral canal). In the postoperative period (up to 40 months), partial recovery of neurological functions was observed in 4 out of 19 patients admitted with paraplegia. Complete recovery was noted in 22 % of patients with neurological disorders, and 36 % of patients did not show any improvement.

P.V. Volkov and A.A. Grin [9] believe that surgical treatment is indicated for spinal injuries with damage to the spinal cord, with the exception of cases of shrapnel wounds (the size of fragments does not exceed 0.5 cm), external cerebrospinal fluid leakage, in the presence of persistent compression of neural structures and post-traumatic instability.

In case of a combined pathology, surgical treatment should be targeted to eliminate the threat to patient life. Spine surgery may be performed only after stabilization of vital functions [10, 11].

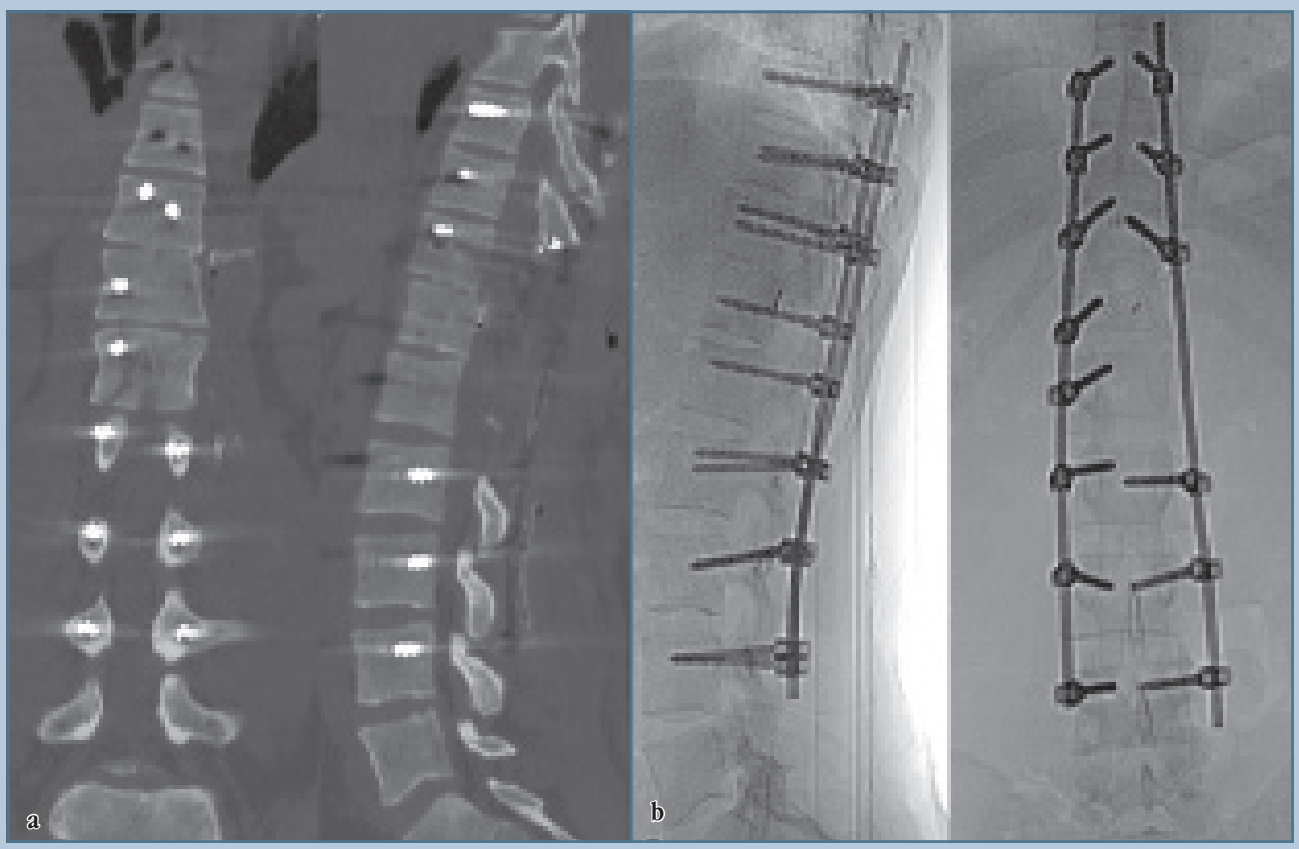

Fig 5
Postoperative data of patient P., 26 years old: **a** – frontal and sagittal CT reconstructions; **b** – spondylograms in frontal and lateral views

Schoenfeld et al. [12] described a series of 50 patients who suffered spinal injuries (mainly in the thoracolumbar spine) during a military mission in Afghanistan. Thirty of them were operated on in the host country and 20 in a hospital in the United States. In the latter case the patients underwent the following surgeries: decompression and stabilization (60 %), stabilization only (25 %) and decompression only (15 %). Out of them, 75 % were operated on through the posterior approach, 5% through the anterior and 20 % underwent a complete reconstruction (360°). Out of patients operated on in Afghanistan, 73 % underwent decompression with stabilization; 20 % of the patients underwent only decompression; 7% of the patients underwent only stabilization; and in most of the patients (97 %) the procedures were performed through the posterior approach. As a result of treatment, an improvement in the neurological status was observed in 5 % of the patients operated on in the United States. Postoperative complications were reported in 20 % of patients and included bedsores (3 patients) and deep vein thrombosis (2 patients). An improvement was noted in 10 % of patients operated on in Afghanistan. Nevertheless, 40 % of the servicemen had postoperative complications: bedsores and venous thrombosis (in 5 and 2 patients, respectively); 23 % of the patients required repeated surgery.

Lawless et al. [13] conducted a meta-analysis of five articles describing five series of patients (383 people) with penetrating spinal cord gunshot wounds (130 with complete spinal cord injury and 158 with incomplete spinal cord injury). In the first group of patients, 80 surgeries were performed; an improvement was noted in 16 patients. In the second group, 103 patients underwent surgery resulted in an improvement in the neurological status of 77 patients. The performed surgeries consisted (in descending order of frequency) of decompression (including removal of fragments entered into the canal), laminectomy, stabilization, debridement, cervical rhizotomy, cervical corpectomy with stabilization and internal fixation. The identified complications were the formation of fistula with cerebrospinal fluid leakage, meningitis and chronic pain syndrome. It is worth pointing out that the study conducted by the authors revealed the absence of significant differences in

the effects of surgical and non-surgical treatment.

A similar meta-analysis was performed by Bin-Alamer et al. [14]. The authors selected and reviewed 10 papers describing data on 1,754 patients with penetrating spinal cord injuries; 92.6 % of which were gunshot and blast injuries. Out of them, 425 patients (28.0 %, mainly with thoracic injuries) underwent surgery; 400 of them (94.1 %) had gunshot injuries. The remaining 1,094 patients received non-surgical treatment; 95.7 % of them had gunshot injuries. The types of surgeries performed included laminectomy, debridement, removal of foreign bodies from the spinal canal and dural closure, including with an allograft and fibrin glue. Later, some patients underwent stabilization and cervical rhizotomy to reduce radicular pain syndrome. Due to surgical intervention, an improvement was registered in 108 (41.5 %) of the patients; neurological status did not change in 146 (56.1 %) patients; 6 (2.3 %) patients showed a worsening course. Postoperative complications were reported in 284 patients, including cerebrospinal fluid leakage/fistula (38.5 %), meningitis (34.6 %) and sepsis (11.5 %), as well as single cases of pulmonary embolism and pneumonia.

In our clinical case, the injury was evaluated as completely unstable. Vertebral displacement and fracture dislocations required stabilization. It was noticeable that the trophic disturbances in the gluteal region had begun after short time from the moment of injury (one day). Patient care was complicated due to severe pain syndrome during turns and concerns about possible secondary injuries to vascular structures and increased displacement of the vertebrae.

A special feature was also the presence of a large contaminated wound in the planned surgical site (in the projection of a skin incision), a soft tissue defect caused by the direct high-velocity impact of an injuring projectile. Considering this mechanism of injury, we expected an increase in the injury region due to secondary changes. Therefore, usually gunshot wounds hold open before cleansing. Secondary stitches are imposed after their complete debridement. Nevertheless, this approach was unsuitable in our case, considering the existence of instrumentation. The decision to use the VAC system provided two objectives: to clean the wound by accelerating the formation of the demarcation area, as well as to approximate its edges due to constant negative pressure. Moreover, there was no recurrence of cerebrospinal fluid leakage.

The short application time of the VAC dressing (10 days with three sponge replacements) help to prevent the formation of biofilms on the hardware and to avoid the replacement or removal of the fixing system.

Despite the nature of the injury and the injury rate of the surgeries performed, the use of the VAC system allowed for the preservation of the outcomes of the stabilization, the prevention of infection and the necessity of replacing the hardware. This treatment strategy provided an opportunity to start rehabilitation activities on the second day after the surgery and to continue rehabilitation treatment at a specialized center three weeks after the completion of the surgical stage.

Conclusion

A clinical case of treatment for a patient with a mine blast wound of the T11 vertebra with an anatomical disruption of the spinal cord and bilateral hemo- and pneumothorax is described. An option for successful treatment of a contaminated gunshot wound at the site of planned surgery with an extensive soft tissue defect using the VAC system is shown. This treatment strategy prevented the formation of biofilms on the elements of the hardware as well as wound infection.

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The authors declare that they have no conflict of interest.
The study was approved by the local ethics committee of the institution.
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