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SURGICAL TREATMENT OF GROSS POSTTRAUMATIC DEFORMATIONS IN THORACIC SPINE

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Rigid severe post-traumatic thoracic spine deformities result from frequent, recent high-energy trauma in children with an increasing frequency due to a variety of reasons. These types of injuries are commonly followed by spinal cord anatomic injury; therefore, the treatment of these patients warrants special attention from the ethical viewpoint. Generally, the only indication for surgical intervention is spinal dysfunction. Considering this and the patients' ordinary severe somatic state, surgical trauma should be minimized as much as possible. However, for adequate deformity correction, effective spine stabilization and restoration of liquorodynamics is necessary. Recent studies have reported the successful use of different methods of dorsal interventions (P/VCR) in cases with unstable damages in children. Here, we present the case of a 15-year-old boy who underwent surgical treatment for coarse post-traumatic thoracic spine deformity with chronic fracture-dislocation of Th7 vertebra.

Keywords: spinal cord injury in children, spinal cord injury, surgical treatment, spondylosynthesis.

ХИРУРГИЧЕСКАЯ КОРРЕКЦИЯ ГРУБОЙ ПОСТТРАВМАТИЧЕСКОЙ ДЕФОРМАЦИИ ГРУДНОГО ОТДЕЛА ПОЗВОНОЧНИКА

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Грубые посттравматические деформации грудного отдела позвоночного столба — это результат высокоэнергетической травмы, которая в последнее время в силу ряда причин все чаще встречается у детей. Данный вид повреждений нередко сопровождается анатомическим повреждением спинного мозга, поэтому лечение таких больных требует особенного внимания в этическом аспекте. Зачастую единственным показанием для хирургического вмешательства является функциональная несостоятельность позвоночника. Учитывая данный факт, а также нередко тяжелое соматическое состояние пациентов, травматичность операции должна быть сокращена до минимума. Наряду с этим необходимо достигнуть адекватной коррекции деформации, надежной стабилизации позвоночного столба и восстановления ликвородинамики. В литературных источниках последних лет все чаще встречаются публикации, посвященные успешному использованию различных вариантов дорзальных вмешательств (P/VCR) при нестабильных повреждениях у детей.
В статье представлен клинический случай хирургического лечения грубой посттравматической деформации грудного отдела позвоночника с застарелым переломовывихом позвонка Th_7 у ребенка 15 лет.

Ключевые слова: повреждение позвоночника у детей, травма спинного мозга, хирургическое лечение, спондилосинтез.

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Introduction

Spinal injury is currently one of the most urgent problems in the fields of modern traumatology as well as in orthopedics and neurosurgery [1, 2]. According to several studies, approximately 22%–30% of all cases of spinal injury involve the thoracic spine [3, 4]. Severe post-traumatic deformities at this level are often accompanied by damage to the spinal cord, wherein restoration of motor functions is extremely challenging under conditions of total neurological deficits [5, 6]. With respect to the ethical aspect, pediatric patients represent a special group [7].

Currently, surgical techniques that were originally proposed for adult patients are being used in the surgical treatment of spinal injury in children [8, 9]. Recently, studies on surgical intervention for unstable injuries, including those that involve the use of combined access approaches (A/P) and various types of osteotomies (SPO, PSO, and VCR) is increasing [10, 11].

With respect to gross post-traumatic deformities of the spinal column, most researchers state that it is necessary to resolve all orthopedic problems during the acute period of trauma [12].

However, often, the serious condition of the patient because of concomitant injuries does not permit the required degree of surgical intervention. This largely concerns reconstructive intervention on the ventral parts of the spinal column [13].

It is also noteworthy that performing surgery via the anterior access approach in patients with long-standing post-traumatic deformities of the thoracic spine may be challenging because of the phenomenon of fibrothorax [14].

The optimal surgical treatment of the gross deformities of the thoracic spine in children can be defined as surgical intervention that enables consistent, adequate mobilization; correction; and stabilization, without significant surgical injury. According to the literature, P/VCR surgeries and various types of segmental vertebrotomy are most suitable in such cases, particularly in patients with an anatomic spinal cord injury [15, 16].

Given the urgency of the problem, we consider it appropriate to present the following clinical observation.

Clinical observation

On September 4, 2014, in the Department of Neurosurgery at Saratov Regional Clinical Hospital, a 15-year-old boy, H., was examined. On August 22, 2014, he had sustained a serious concomitant injury in a traffic accident. From the scene of the accident, he was taken to the district hospital of the city of Atkarsk, Saratov region. He was treated in the intensive care unit for four days and underwent intensive treatment aimed at normalizing his vital signs. On August 26, 2014, he was transferred to the intensive care unit of the regional clinical hospital in a reanimation ambulance car of the regional ambulance service and intensive care was continued. After a comprehensive examination that included a computed tomography (CT) scan, he was diagnosed with the following findings: closed craniocerebral injury with a moderate brain contusion, laminar subdural hematoma in the right hemisphere, closed complicated trauma of the thoracic spine with dislocation fracture of vertebra Th_7, lower paraplegia, dysfunction of the pelvic organs, closed chest trauma with a fracture of ribs 3–7 on the right and left, bilateral hemothorax, closed trauma of the trunks of the right brachial plexus, and upper coarse monoparesis on the right. Among the above-mentioned findings, bilateral hemothorax was eliminated following active drainage of both pleural cavities. After the stabilization of vital signs, he was examined by a consultant from the institute.

Physical and physiological status: During the time of the examination, the patient's condition was stable and moderately severe. He complained of constant pain in the thoracic spine, weakness in the muscles of the right arm, and absence of arbitrary movements in the lower limbs. Pain sharply increased with body movement. Attention was drawn to the pronounced kyphotic deformity in the thoracic spine. The patient was forcible mady to lie in the supine position. The long muscles of the back were very tense. Palpation in the projection of ribs 3–7 on the right and left was painful. Respiration was vesicular and was equally weak on both sides, mainly in the lower parts of the thorax. The abdomen was not inflated and was soft on palpation in all parts. His urine was of normal color and was excreted through a permanent urethral catheter. Defecation was unconscious. No trophic damage to the skin was detected.

Neurological status: The patient was conscious and cooperative. Cranial nerves had no pathology. Pupils were equall on both sides, and photoreaction was vital and symmetrical. The muscular tone and volume of the active movements in the left arm were within the normal limits. On the right, there was a coarse upper total monoparesis. The muscular strength was reduced to 1 point, and sensitivity was lost to the level of deep hypesthesia. The tissues of the right hand were atonic and pasty. Movement in the legs was absent; the muscles were hypotrophic. Tendon reflexes from the lower extremities were absent. All kinds of sensitivity are anesthesia. The functions of the pelvic organs are disordered by the central type.

Radiological examinations (including radiography and CT scan) revealed the dislocated fracture of vertebra Th_7 in the patient, with the formation of a gross, multiplanar deformity of the thoracic spine at this level (Fig. 1). The angle of kyphosis was 42° [17]. The vertebral bodies Th_7 and Th_8 were posteriorly displaced with displacement along the axis behind vertebra Th_6 for the full body height and one-fourth part, respectively. Vertebra Th_7 was closely adjacent to the posterior edge of the vertebral body Th_6, overlapping the vertebral canal by 100%. There was a compression comminuted fracture of vertebra Th_7; body height was reduced by one-third, and the ventral section was deformed. There was a fracture of the posterior ring with separation of the lower articular processes of the arc of vertebra Th_6 and the upper articular processes of the arch of vertebra Th_7. Fragments of the articular processes were located in the soft tissues in the projection of the vertebral canal of vertebra Th_7. There were multiple fractures of the ribs on both sides (ribs 3–7), some of which were comminuted. In the pleural cavity, there were effects of drained hemothorax with the phenomenon of secondary adhesive pleurisy.

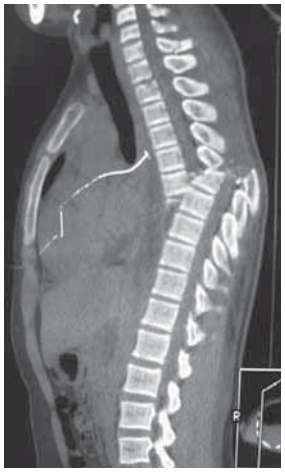

Fig. 1. CT scan of the spine of patient H. before surgery

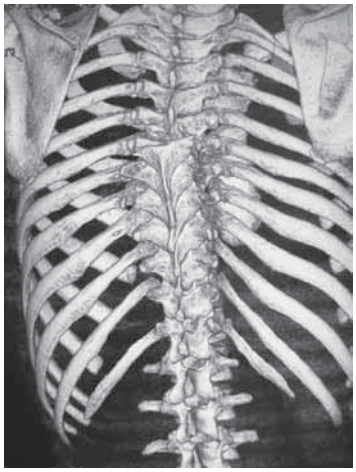

Fig. 2. CT scan of the spine of patient H. before surgery (3D reconstruction)

A gross deformity of the thoracic spine accompanied by intense pain syndrome markedly hampered the patient's further rehabilitation. Thus, considering his relatively satisfactory state, the decision to perform planned surgical intervention was taken. His parents provided their consent for performing the surgery and using their personal data.

On September 6, 2014, the patient was transferred to the Department of Neurosurgery of the institute. As part of the preoperative preparation, several additional health investigations were conducted, including laboratory, radiographical, and electrophysiological evaluations.

Low-amplitude M-responses (≤0.1 mV) were recorded by electroneuromyography (ENMG) of the femoral, peroneal, and tibial nerves. It was not feasible to obtain late antidromic responses from the spinal cord motoneurons. Using magnetic stimulation at the level of the lumbar thickening of the spinal cord and transcranial magnetic stimulation (TMS), evoked muscle responses (EMR) were not recorded. Data obtained in the neurophysiological study indicated a gross lesion of the spinal cord with a complete conduction disorder at the level of trauma. The decrease in the M-responses of the median nerve (≤2.1 mV), particularly the axillary nerve (0.4 mV), with spontaneous activity in the form of fibrillation potential in the deltoid muscle and abductor muscle of the thumb indicated axonal damage of the trunks of the brachial plexus.

To identify several parameters of the deformity, a repeat CT scan with 3D reconstruction was performed (Fig. 2).

On September 8, 2014, the patient underwent surgery in the prone position; a 23-cm long incision on the skin and subcutaneous tissue was made along the line of the spinous processes from Th_3 to Th_{11}. The above-mentioned posterior bone structures of the vertebrae were skeletonized. The gross bayonet-shaped kyphotic deformity of the thoracic spine was apparent. In the wound, the posterior structures of vertebra Th_7 were visualized with the upper articular and transverse processes detached as well as the

gaping vertebral canal and the partially intervertebral disc. The dura mater (DM) was crushed, was perforated in several places with bone fragments, was "overflowed" through the edge of vertebra Th_7, and was compressed between the fibrous ring of the disc and the arch of the overlying vertebra. Through the breaks in the DM, cerebral detritus flowed out. Resection of the spinous process and the arch of vertebra Th_7 was performed; it was extirpated along with the adjacent discs, following which vertebra Th_6 was fully visible. In the vertebral bodies of Th_4, Th_6, Th_8, and Th_9, pedicle screws were installed on both sides under the control of an electronic and optical transducer. Supporting elements on both sides were connected with a rod, and an attempt to correct the deformity was made; however, the result was unsatisfactory. Control roentgenoscopy showed the inefficiency of the reduction maneuver, after which the upper part of the spinal column became vertical such that vertebral body Th_6 was dislocated with respect to vertebra Th_8 by almost the entire longitudinal diameter. Therefore, the decision to increase the volume of bone resection was made. Costotransversectomy and resection of vertebral body Th_8 were performed. An additional pair of screws was installed in the body of vertebra Th_{10}. Two rods were re-assembled; then, following reduction, the correct axis of the spine was restored. In the defect formed between vertebral bodies Th_6 and Th_9, a mesh endofixator was installed and filled with autobone that was rigidly fixed by contracting the rods of the structure. The nodes of the system were completely fixed. After control radiography, hemostasis, and drainage, the wound was sutured layerwise. The patient was rotated so that he was lying on his back, and revision and neurolysis of the trunks of the right brachial plexus were performed.

After surgery, the patient was treated in the intensive care unit for two days where he underwent a course of intensive pharmacological therapy. On postoperative day 3, he was transferred to the general ward where rehabilitation was continued. Drainage was removed on postoperative day 4. On postoperative day 10, a control CT scan of the thoracic spine (Fig. 3) was performed, and his gradual activation in a vertical position was started. The wound healed by primary intention; the sutures were removed on postoperative day 14; he was discharged three weeks after surgery in a satisfactory condition with recommendations to continue rehabilitation in a specialized center.

A follow-up examination and CT scan performed 2.5 years after surgery revealed no loss of the achieved correction (Fig. 4). Between the Th_6 and Th_9 vertebral bodies, there was formation of the bone-metal block. The neurological status was unchanged. The patient moved around in a wheelchair and did not experience pain syndrome at the site of surgery.

A control electrophysiological examination of our patient showed a more remarkable reduction in the ENMG data of the peripheral nerves of the lower limbs. When nerves from the muscles of the foot and lower leg were stimulated, no muscle response was registered. In addition, there were no EMR on performing TMS. The dynamics of the ENMG indices of the median and axillary nerves was positive; this was confirmed by an increased amplitude of M-responses.

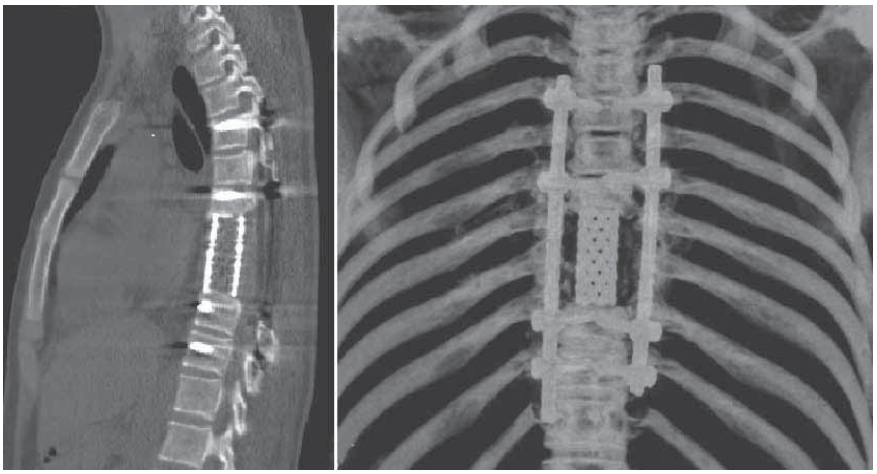

Fig. 3. CT scan of the thoracic spine of patient H. after surgery

Fig. 4. CT scan of the thoracic spine of patient H. 2.5 years after surgery

Discussion

Gross post-traumatic deformities of the thoracic spine are generally caused by high-energy injuries (e.g., road traffic accident and fall from a height) and have recently become more prevalent among children owing to several reasons. This type of injury is often accompanied by anatomical damage to the spinal cord; therefore, the treatment of patients with such injuries requires special attention with respect to ethical aspects, considering that the only indication for surgical intervention is often the functional failure of the spine [18, 19]. It is also noteworthy that the severity of the injury can cause various pathological conditions that do not permit deformity correction during the acute period. Thus, surgeons often encounter gross long-standing deformities of the thoracic spine, wherein all structures surrounding the vertebral column, including the thorax and blood vessels, are involved in the fibrous process. The degree of surgical intervention in such situations is generally determined by mobilizing and correcting the spine deformity. In our opinion, in cases similar to our clinical example, where there is a gross long-standing spinal column deformity accompanied by a pronounced dislocation component, an anatomical spinal cord injury, and an uncertain prognosis for the restoration of function, the intervention must be minimally traumatic. Furthermore, the major objectives of intervention should be fulfilled; these include adequate correction of the deformity, reliable stabilization of the spinal column, and restoration of cerebrospinal fluid circulation.

In the present case, the dorsal access approach appeared to be the most preferable, considering the patient's condition. The existing method of mobilizing vertebrotomy enabled the resection of a part of the required length of the vertebral column. Dorsal instrumentation had greater repositioning capabilities than the ventral instrumentation. Considering concomitant thoracic injuries, performing surgery via the anterior access approach can be challenging. In addition, the performance of ventral surgery that is traumatic in nature is not indicated in a child with a severe concomitant injury. It is also noteworthy that the intraoperative repositioning maneuver for the correction of gross long-standing deformities of the thoracic spine may be ineffective owing to fibrosis of the paravertebral structures, primarily the thorax. Moreover, the use of excessive traction in our patient involved the risk of damage to blood and lymphatic vessels. Thus, in such cases, the restoration of the normal axis of the spinal column should be performed by increasing the bone resection volume by the type of shortening vertebrotomy.

Conclusion

Surgical intervention enabled the restoration of the normal axis of the spinal column, the reconstruction of the spinal canal, and the reliable stabilization of the thoracic spine. Surgery that was performed through the dorsal access approach enabled the reduction of the degree of intraoperative trauma and blood loss; in turn, this enabled the shortening of the recovery period, thereby facilitating the early initiation of rehabilitation for the patient.

Information on funding and conflict of interest

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