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REHABILITATION OF CHILDREN AT THE INPATIENT STAGE AFTER SURGICAL TREATMENT OF UNSTABLE FRACTURES OF THE THORACOLUMBAR AND LUMBAR SPINE

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Introduction. The modern approach to the treatment of unstable fractures of the thoracolumbar and lumbar spine in children is surgical stabilization at the early stages after trauma by using metal structures that quickly restore vertical functionality to the patient and shorten the period of inpatient treatment. However, the issues related to restorative treatment have not been sufficiently addressed.

Aim. To develop an algorithm for restorative treatment of children at the inpatient stage after surgical treatment of unstable uncomplicated fractures of the thoracolumbar and lumbar spine.

Material and methods. Based on the results of treatment of 73 patients aged 9 to 17 years with unstable uncomplicated vertebral fractures, an algorithm of stage-by-stage rehabilitation by means of therapeutic gymnastics depending on the severity of the injury, method of surgical stabilization of the spine, physical condition of the child, and time passed after the operation was developed.

Results and discussion. The use of differentiated groups of respiratory gymnastics and isometric and dynamic exercises for muscle groups restored vertical functionality to patients in 1–3 days after surgery, restored spine and motor functions, and shortened the duration of inpatient treatment to a range of 10–14 days.

Conclusion. The developed algorithm for physical rehabilitation of children after surgical treatment of unstable injuries of the thoracic and lumbar spine by using metal structures at the inpatient stage contributed to the selection of the most rational and effective program of restorative treatment.

Keywords: children; instable spine fractures; rehabilitation; inpatient rehabilitation; treatment strategy.

РЕАБИЛИТАЦИЯ ДЕТЕЙ НА СТАЦИОНАРНОМ ЭТАПЕ ПОСЛЕ ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ НЕСТАБИЛЬНЫХ ПЕРЕЛОМОВ ГРУДОПОЯСНИЧНОГО И ПОЯСНИЧНОГО ОТДЕЛОВ ПОЗВОНОЧНИКА

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Введение. Современной тактикой лечения нестабильных переломов грудопоясничного и поясничного отделов позвоночника у детей является их хирургическая стабилизация в ранние сроки после травмы с использованием металлоконструкций, что позволяет быстро вертикализировать пациента и сократить сроки стационарного лечения. Однако вопросы восстановительного лечения разработаны недостаточно.

Цель исследования — разработать алгоритм восстановительного лечения детей на стационарном этапе после хирургического лечения нестабильных неосложненных переломов грудопоясничного и поясничного отделов позвоночника.

Материалы и методы. На основании результатов лечения 73 пациентов с нестабильными неосложненными переломами позвоночника в возрасте от 9 до 17 лет разработан алгоритм поэтапной реабилитации средствами лечебной гимнастики в зависимости от тяжести полученной травмы, метода хирургической стабилизации позвоночника, от соматического состояния ребенка, его физической подготовки и от срока, прошедшего после операции.

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Результаты и обсуждение. Дифференцированные комплексы упражнений дыхательной гимнастики, изометрических и динамических упражнений для мышечных групп позволили вертикализировать пациентов после операции в 1–3-и сутки, восстановить опороспособность позвоночника и двигательные функции и сократить срок стационарного лечения до 10–14 дней.

Заключение. Разработанный алгоритм физической реабилитации детей после хирургического лечения нестабильных повреждений грудного и поясничного отделов позвоночника с использованием металлоконструкций на стационарном этапе способствует выбору наиболее рациональной и результативной программы восстановительного лечения.

Ключевые слова: дети; нестабильные переломы позвоночника; реабилитация; стационарный этап; алгоритм лечения.

Introduction

In recent years, there has been an increase in the number of children with spinal injuries of different locations. According to the statistical data of St. Petersburg children's hospital, the number of pediatric patients with vertebral fractures of the musculoskeletal system has increased from 5% to 7% between 2000 and 2015. The most common spinal traumas observed in pediatric patients are vertebral compression fractures. However, in the structure of the spinal column injuries, the number of unstable and complicated vertebral fractures of various locations has increased. According to a trial by Russian researchers, the total prevalence of these types of injuries is 0.2% of all vertebral fractures. Among severe spinal injuries, unstable vertebral fractures are the most common (77%) [1].

We have described in detail the various approaches and types of surgical interventions for pediatric patients with unstable vertebral fractures. Surgical technologies used in the initial hours and days after the injury enable the elimination of instability of the spinal motion segment and restoration of the correct anatomy of the injured spine [2]. Dorsal and ventral approaches during surgical treatment provide favorable anatomical and functional results, thus shortening the hospital stay to 10–14 days [3, 4].

However, it is noteworthy that modern surgical technologies for treating these patients require appropriate physical rehabilitation methods. At present, there practically are no methods involving a combined approach for rehabilitation treatment of pediatric patients with unstable spinal injuries.

The majority of such patients are currently receiving treatment according to previously developed methods. Many authors have reported that commonly, particularly in the remote regions of Russia, rehabilitation treatment for uncomplicated vertebral fractures, particularly for compression fractures, is performed as per the principles proposed by E.F. Dreving in 1942 [5]. This treatment program is divided into 4 stages to restore the patient's physical capabilities, corresponding to the anatomical and morphological changes in the bone tissue of the compressed vertebrae. The program involves a long-term compliance with bed regime (up to 2 months) and performance of isotonic and isometric exercises [6].

However, modern standards of treatment involve a more intense treatment process with a reduction in the hospital stay and transfer of the rehabilitation measures to outpatient settings [7, 8]. In contrast, the development of new surgical technologies, including transpedicular fixation of the vertebrae with metal structures and fusion using Pyramesh, for treating unstable spinal fractures in children enables an early elimination of spinal instability [3, 4].

Some previous trials have indicated the periodic performances of motor activity (walking, sitting, and therapeutic exercises) without a clear physiological justification in terms of rehabilitation treatment.

The scientific publications devoted to rehabilitation treatment of pediatric patients with unstable vertebral fractures of the thoracic and lumbar spine following surgical intervention contain some recommendations without proper physiological justification in terms of physical rehabilitation involving expansion of the motor regime, particularly the vertical position, dosed walking, and sitting. Further, there is no indication of continuity and phasing of the treatment.

Aim. The study aimed to develop an algorithm for the rehabilitation treatment at a steady state stage of pediatric patients with unstable vertebral fractures of the thoracolumbar and lumbar spine following surgical intervention.

Materials and methods

In total, 73 pediatric patients (9–17 years) with unstable uncomplicated spinal fractures were observed. 72% of these patients were hospitalized in the Department of Spinal Pathology and Neurosurgery of the Turner Scientific and Research Institute for Children's Orthopedics on the first day after injury, whereas 28% were hospitalized after 3 days. In 44.7% of the patients, the spinal injury was localized to the thoracolumbar region, whereas in 55.3%, it was localized to the lumbar region. In total, 96% (70 patients) of the patients were diagnosed with a burst fracture and 4% (3 patients) with a chance fracture (according to the F. Denis classification).

On the basis of the age-related anatomical and physiological features of the spine, condition of the muscular corset, and functional parameters of the cardiovascular and respiratory systems, the observed patients were divided into 2 age groups: 9–12 years and 13–16 years. The indicators measured during the study, which characterized the functional state of organs and systems, were compared with the age norms.

All the patients were examined comprehensively. During the clinical examination at admission, which was performed with the patient in the prone position, attention was paid to skin integrity, presence of hematomas and pathological swelling, condition of the muscular-ligamentous apparatus, and the severity of the physiological spinal curvatures. The functional parameters of the cardiovascular and respiratory systems, including pulse rate (PR), were measured; arterial blood pressure (BP) and respiratory rate (RR) were monitored during the postoperative period in the intensive care unit and throughout the postoperative follow-up at the various stages of rehabilitation treatment. Neurological examination assessed the patient's neurological status and emotional and psychological state, and it identified possible signs of spinal trauma. The spine roentgenogram was developed using 2 projections: a computed tomography of the spine to accurately identify the injuries and magnetic resonance imaging to exclude damage to the central canal of the spinal cord and to the spinal cord. Depending on the clinical and radiological state of the structural injuries to the vertebrae and on the vertebral-motor segment instability, all patients underwent surgical treatments, such as posterior indirect reposition and stabilization with transpedicular fixation in case of burst fracture observed with spondylosyndesis and fusion with reconstruction of the anterior and middle columns at the damage level of Pyramesh with a pronounced degree of destruction and displacement of the vertebral bodies.

In the preoperative period, the pediatric patients required physical rehabilitation treatment when the postoperative surgical treatment was delayed owing to late hospital admission.

After the treatment, all patients received rehabilitation treatment depending on the trauma and its severity, method of surgical spine stabilization, patient's physical condition and fitness, and the postoperative duration. The rehabilitation exercises included respiratory gymnastics and isometric and isotonic exercises.

Results and discussion

An analysis of the anamnestic data regarding the spinal injury timing was performed. Moreover, results of the initial examination and specialized examination were analyzed.

When a patient with unstable spine injuries was admitted, during the initial orthopedic neurological examination and at the stages of the in-depth specialized examination, the need for preoperative preparation using therapeutic gymnastics was determined. The preoperative preparation tasks were determined as per the trauma severity and its extensiveness; indices of orthopedic, neurological, and somatic status; and forthcoming surgical intervention duration. These tasks included the following:

- creation of rest conditions, such as laying on the shield with rollers under the knee joints and feet rest at an angle of 90°;
- formation of the correct breathing pattern (static); and
- reduction or removal of anxiety and depressive syndrome caused by the trauma and the forthcoming surgery.

The general condition of the patients was indicated as moderate or severe. While analyzing the clinical examination results, pain in the spine trauma area was observed and the frequency of respiration and pulse was increased by 18%–20%

compared with the age indices. In all pediatric patients, regardless of their age, deviations in the psycho-emotional state caused by pain due to the pain syndrome, negative emotions associated with the circumstances of the trauma, and fear of the forthcoming surgical intervention were observed. The psycho-emotional state was stabilized using sedatives that are a part of the preoperative premedication complex and by creating a favorable psychological climate.

Objectives of the rehabilitation treatment in the postoperative period included the following:

- restoration of the correct breathing pattern;
- improvement in blood circulation and metabolic processes in the tissues that would have otherwise become abnormal due to the trauma or forthcoming surgical intervention;
- prevention of congestion in the lungs and intestines;
- stimulation of psycho-emotional tone and switching of patient's attention from the operational scars to positive impressions;
- restoration of coordination skills necessary for walking by stabilizing the spine after the surgical intervention;
- increase in the contractile ability of the muscles and in their strength endurance with the subsequent restoration of the muscular corset.

The tasks set by the means of therapeutic gymnastics were performed at the stationary stage on postoperative day 1 (postoperative department ward) in the supine position while observing strict bed rest. The complex exercises of respiratory gymnastics, including the pronunciation of the sounds "Ʒ," "Z," and "S" at exhalation when all parts of the chest and lungs are consistently involved in the respiratory process, helped in restoring the type, rhythm, and respiration rate in accordance with the age norms. Only 12% of the patients had a respiratory and PR that exceeded the age index by 17–21%; this was attributable to the consequences of the trauma severity and postoperative intervention. BP in all the patients was within the normal limits for their ages. Isotonic exercises for the chest and abdomen muscles aimed to eliminate congestion and prevent possible complications. The patients also performed dynamic exercises for the distal parts of the upper and lower extremities. Thus, on postoperative day 1, all tasks for preventing hypodynamia and creating a favorable psychological climate were performed.

The general condition of all the patients on postoperative day 2 was observed to be satisfactory, allowing their transfer to the intensive care ward of the spinal pathology department for the next stage of physical rehabilitation. This stage involved the preparation for verticalization and restoration of the spinal support capacity. The complex exercises performed on postoperative day 1 were expanded due to an increase in the exposure and number of repetitions of exercises already mastered post operation. For early verticalization preparation, the possibility of which in the early period was provided by surgical stabilization of the damaged spine, the dynamic exercises for the joints of the upper and lower extremities were introduced. Patients performed the bending movements of the knee and hip joints while lying and with their heels sliding on the surface of the bed to avoid any additional load on the lumbar spine. The bending of the hip joint was done with external rotation. It can be considered erroneous to use physical therapy exercises such as "spinning the pedals in the supine position," vertical and horizontal "scissors," and raising of straight legs, particularly in cases of lumbar spine injuries because these exercises actively involve the muscles of the hip flexors that begin from the 12th thoracic and 1–4th lumbar vertebrae and the lumbar spine of the diaphragm. The exercises lead to passive over-extension of the lumbar spine and additional compression of the anterior parts of the vertebrae. Thus, a set of selected dynamic exercises are justifiable from an anatomical and biomechanical point of view.

In the verticalization preparation period on postoperative days 1–3, depending on the trauma severity and surgical intervention and the somatic state and age, the patients were taught to lie on their stomachs, excluding the rotational movements of the spine and pelvis to prevent the surgical hardware ("rolling-log") displacement. Verticalization is performed with the patients lying on their stomachs by flexing the arms at the elbow joints and resting against the bed with the help of their palms. The patient alternately lowers one leg at a time, rises under the rehabilitation physician's supervision, and walks. The halt in the vertical position was strictly dosed with the unloading of the spine in the prone position.

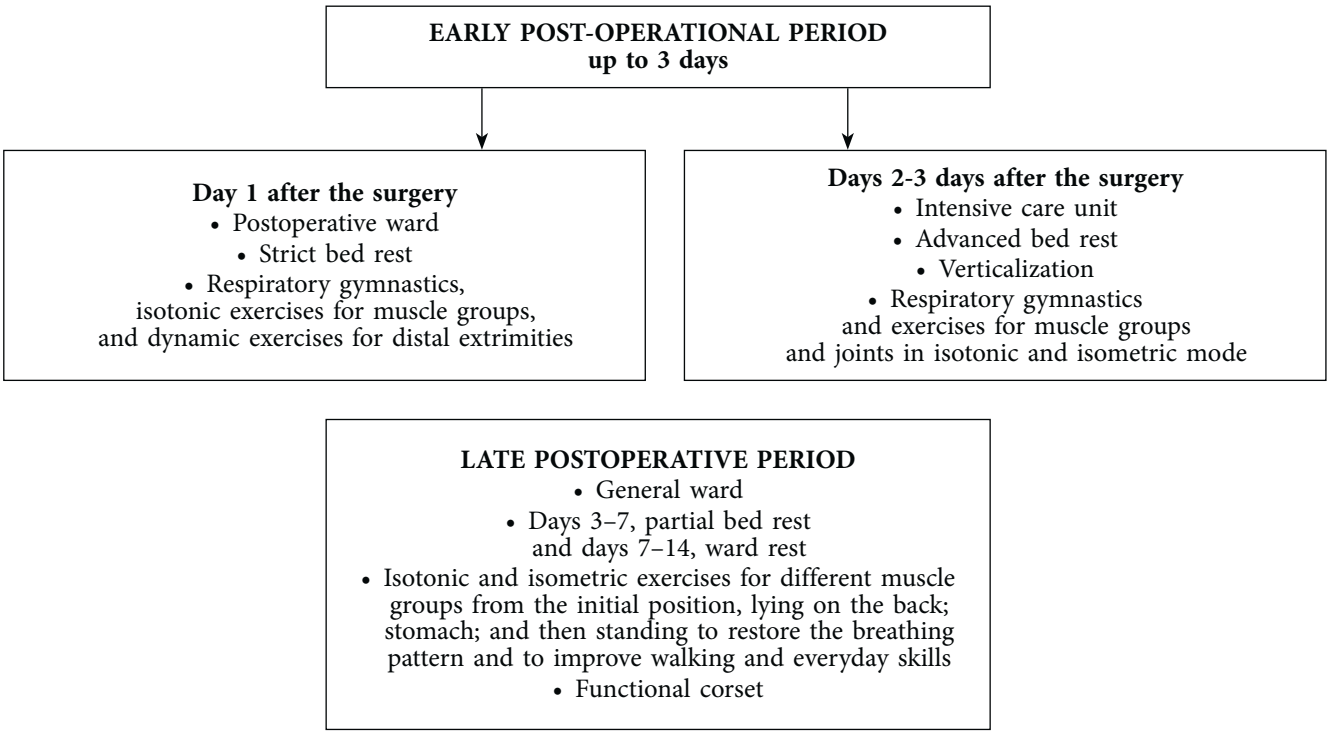

Fig. 1. Algorithm of the physical rehabilitation of pediatric patients following surgical intervention for unstable vertebral injuries of the thoracolumbar and lumbar spine using surgical hardware in the steady state stage

When the patient was transferred to the general ward of the Traumatology and Orthopedic department on postoperative day 3 or 4, the motor activity gradually increased and partial bed rest was observed. Assessment of the overall physical condition of the patient, severity of the consequences of trauma and surgical intervention, anatomical and functional state of the muscular corset, and age and psychological characteristics served as the basis for the compilation of individual complexes of therapeutic gymnastics at this stage of physical rehabilitation. Monitoring the RR, PR, BP, and muscle tone at rest and in tension (based on palpation control) enabled the determination of the appropriate recommendations for compiling a set of therapeutic exercises from various initial positions, such as lying on the stomach, lying on the back, and standing. To restore the chest excursion and breathing pattern, it is necessary to perform static and dynamic breathing exercises. Exercises for different muscle groups were performed in both isometric (static) and isotonic (dynamic) modes with a gradual increase in the muscle load owing to an increase in the exercise exposures and the number of repetitions. The patient was trained on the elements of domestic services, acceptable body bending with a straight back due to bending in the hip joints, wall-sitting, and turning with a small amplitude of the trunk.

The patient's halt in a vertical position and his/her walk were strictly dosed according to their distance, time, and subjective sensations with subsequent unloading of the spine in the prone position. At this stage of physical rehabilitation, walking was performed in a functional corset with stiffening ribs and elastic ties.

These results enabled us to develop an algorithm using surgical hardware for the physical rehabilitation of patients with unstable vertebral injuries of the thoracolumbar and lumbar spine at a steady state stage following surgical intervention (Fig. 1).

The proposed algorithm enabled us to resolve all the problems of rehabilitation treatment in children with trauma at the stationary stage and to restore the spinal support capacity and motor functions, enabling the shortening of the postoperative hospital stay to 10–14 days. The patients were discharged with recommendations for wearing a functional corset and continuing the course of rehabilitation treatment during the outpatient stage.

Conclusion

Modern treatment approaches for unstable vertebral injuries of the thoracic and lumbar spine in children enable surgical stabilization of the

damaged spine with the use of the most advanced surgical hardware during the initial hours and days after trauma. Physical rehabilitation of patients during the postoperative period is performed in the hospital in various stages, according to the developed algorithm. In addition, exercises of therapeutic gymnastics are prescribed, considering the severity and volume of the spine trauma and surgical intervention, duration since the surgery, patient's condition, functional parameters of the cardiovascular and respiratory system, and functional features of the muscular corset. Gradual expansion of the postoperative regimen, respiratory gymnastics, and dosed load on the spine with a combination of isotonic and isometric exercises for the muscle groups allow an early (1–3 days) preparation of the patient for verticalization after the surgery, restore the spinal support capacity and motor functions, and reduce the hospital stay to 10–14 days. The algorithm developed for the physical rehabilitation of pediatric patients following surgical intervention for unstable vertebral injuries of the thoracic and lumbar spine using surgical hardware at the steady state stage aids the selection of the most rational and effective program of rehabilitation treatment.

Funding and conflict of interest

This study was conducted within the state contract framework for performing research as per the Union State program on the topic, Development of new spinal systems with the use of prototyping technologies in the surgical treatment of children with severe congenital deformities and spinal injuries.

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