INTRAOPERATIVE DIAGNOSIS OF NEUROLOGICAL COMPLICATIONS IN SURGERY OF SEVERE SCOLIOSIS: REPORT OF CLINICAL CASES

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Clinical observations of 13- and 15-year-old patients with severe (118° and 133°) idiopathic scoliosis, subjected to operative correction with the use of segmental instrumentation are presented. Intraoperative monitoring of the spinal cord function was performed by recording motor potentials of the brain and skin thermometry from the lower limbs (authors' technique). During the operation, there was a gradual decrease in potentials in one case and sharp in another, with no changes in cutaneous temperature. Based on the data of skin thermometry, surgeons decided not to remove the implant and to bring the operation to completion in both cases. In the postoperative period, neurological complications were not revealed. The conclusion is made about the advisability of including the skin thermometry in a complex of intraoperative monitoring of spinal cord function in patients with spine deformities.
Key Words: idiopathic scoliosis, intraoperative monitoring, skin thermometry.

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Almost any intervention into the anterior and posterior regions of the spine is associated with a risk of developing neurological deficit resulting from worsened blood flow or mechanical injury to the spine and its structures. Various methods have been used to solve the problems related to prevention and early diagnosis of these severe complications. First described in 1973, the Stagnara wake up test [5] allows one to assess the functional integrity of the entire locomotor system, including the upper motor neuron and motor units. This test is considered to be highly reliable but has a number of shortcomings. For example, it does not evaluate the functional integrity of individual muscle groups and nerve trunks or the sensory function. In some cases, there are problems with waking up the patients. Finally, the test shows the situation at a specific moment rather than in dynamics, which is extremely important taking into account the surgery duration. Somatosensory-evoked potentials (SSEPs) are recorded by stimulating one of the peripheral nerves [4]. The recording electrodes are placed either cutaneously or subcutaneously. The percentage of false-positive results is ≤1.4 % [3], but only in patients who were neurologically intact before the surgery. Otherwise, the reliability of the method when using single-channel SSEP recording decreases to ≤75 %. Motor-evoked potentials (MEPs) elicited by stimulation of the brain or spinal cord allow one to assess the function of all parts of the nervous system or the nervous system portion located distal to the stimulation level, respectively [2]. Overall, the reliability of MEPs is considered to be lower than that of SSEPs. Since each of the methods listed above can yield both false-positive and false-negative results, it is reasonable to use their combination to enhance the reliability of the findings.

We have elaborated the «Method for intraoperative diagnosis of neurological complications in operations on spine» [1]. The objective of this technique is to detect a neurological complication in the early intraoperative period, which would allow a spine surgeon to modify the tactics used and to restore the functional integrity of the nervous system. The result is achieved because spinal cord dysfunction of any etiology (mechanical, traction, or vascular injury) leads to spinal shock. The pathogenesis of shock involves disruption of regulatory effects in the upper autonomic centers in the cervical and upper thoracic spine. Bradycardia and hypotension are the main autonomic clinical symptoms of spinal cord shock. Loss of the vasomotor tone manifests itself as hyperemia of skin and internal organs aggravating the signs of hypotension. These manifestations are also accompanied by elevated leg skin temperature. Continuous thermometry of the skin of the lower extremities allows one to intraoperatively detect temperature elevation shortly after spinal cord injury and development of spinal shock and to diagnose neurological complications.

The procedure was carried out as follows. Prior to the surgery, sensors of a digital thermographic imaging unit (measurement accuracy, up to 0.1°) were attached to the posterior surface of both shanks. The unit was calibrated until the results were constant and accurate. The temperature data were recorded intraoperatively, with the minimal interval of 5 min. Special focus was placed on measurements made during the period being most dangerous in terms of the possible risk of developing neurological complications. If temperature increased by at least 0.5°, the association between the corresponding changes and surgeons' actions was looked for. If the surgeons' actions were associated with possible risk of damaging the nervous system, neurological complications were reported. This method does not distract the surgeon from the intervention and does not affect surgery duration. It has been included into the set of procedures for spinal cord monitoring used upon any surgeries for spine deformity correction.

The objective of this study was to analyze the results of using the elaborated method in challenging clinical situations.

Clinical case 1. A 13-year-old female patient R. was admitted to hospital on January 27, 2017. After examination, the patient was diagnosed with idiopathic uncomplicated progressive subcompensated rigid right-sided thoracic kyphoscoliosis, grade IV (scoliotic component 133°, kyphotic component 72°), posterior right-sided rib hump deformity, chronic non-acute superficial gastritis, grade 1 mitral valve prolapse (hemodynamically non-significant). MRI showed no pathological changes in the contents of the spinal canal.

In accordance with the treatment strategy approved during the clinical discussion, a multi-stage surgery was conducted on January 30, 2017 (surgeon, V.V. Novikov), involving:

– right thoracotomy, mobilizing T8–T11 discectomy, and interbody fusion using bone autograft;

– skeletal traction applied to the cranium and shanks;

– Smith-Petersen osteotomy (SPO) at T8–T11;

– correction of spine deformity using segmental instrumentation from T3 to L4, posterior fusion using bone autograft.

Integrated neuromonitoring was performed during the entire surgery: the motor-evoked potentials were recorded and skin temperature was measured. The amplitude of motor-evoked potentials decreased uniformly and gradually during the entire posterior stage of the intervention, starting with skin incision. By the time when corrective manipulations were started, no potentials have been recorded. Lumbar puncture was performed at the L5–S1 level to obtain cerebrospinal fluid samples. No signs of CSF blockage were detected. We failed to perform the Wake-up test. Steady-state hemodynamics and no elevation of skin temperature in the lower extremities were observed during the surgery.

As reported by the Department of Functional Diagnosis, the background responses from the muscles of both lower extremities were strong and had uniform amplitudes. During the surgery, the amplitudes of the potentials reduced by 35 %; at the end of the surgery, the response from the muscles of both extremities decreased abruptly by >50 %.

Surgery duration was 4 h 40 min; total blood loss, 750 ml.

The patient recovering from anesthesia was examined by a neurologist; no pathological symptoms were found. Control spondylograms showed that significant correction of the initial spine deformity had been achieved; no signs of penetration of transpedicular screws into the spinal canal lumen were detected (Fig. 1). The patient was allowed to get up from bed and walk on the third postoperative day and was discharged in satisfactory condition on February 15, 2017.

Clinical case 2. A 15-year-old female patient Ts. was admitted to hospital on November 27, 2017. After examination, she was diagnosed with idiopathic uncomplicated progressive subcompensated rigid right-sided thoracic scoliosis, grade IV (118°), with a lumbar counter curve (72°), posterior right-sided rib hump deformity, chronic non-acute superficial gastritis, and mild myopia. MRI showed no pathological changes in the contents of the spinal canal.

In accordance with the treatment strategy approved during the clinical discussion, a multi-stage surgery was conducted on November 21, 2017 (surgeon, A.S. Vasyura), which involved:

– skeletal traction applied to the cranium and shanks;

– Smith-Petersen osteotomy at T7–T10;

– correction of spinal deformity using segmental instrumentation from T4 to L4; posterior fusion with a bone autograft.

As reported by the Department of Functional Diagnosis, the background responses from the muscles of both lower extremities were strong and had uniform amplitudes. Unaltered responses to motor-evoked potentials (MEPs) were recorded at the stage of the left rod placement.

After the second (stabilizing) rod had been placed on the convex side of the deformity, no motor-evoked potentials were recorded up to the end of the surgery. The hemodynamics and skin temperature recorded in the lower extremities were unaltered. The Wake-up test showed that lower extremity movements were preserved.

Surgery duration was 4 h 20 min; total blood loss, 1350 ml.

After the patient recovered from anesthesia, right lower extremity maintained full range of motion, while the left one maintained a partial range of motion.

The patient was examined by a neurologist in the morning of the second day; no pathological symptoms were found. Control spondylograms showed that significant correction of the initial spine deformity had been achieved; no signs of penetration of transpedicular screws into the spinal canal lumen were detected (Fig. 2). The patient was allowed to get up from bed and walk on the third postoperative day and was discharged in satisfactory condition on December 4, 2017.

Discussion

The reported clinical cases have both similarities and differences. Both patients were adolescents and had spine deformities classified as ultra-severe but neurologically intact at baseline. None of them had a past history of neurological disorders and both underwent a massive surgery resulting

Fig. 1
Radiographs of 13-year-old patient R.: **a** – preoperative scoliotic deformity 131°; **b** – thoracic kyphosis 67°; lumbar lordosis 53°; **c** – postoperative scoliotic deformity 46°; **d** – thoracic kyphosis 25°, lumbar lordosis 47°

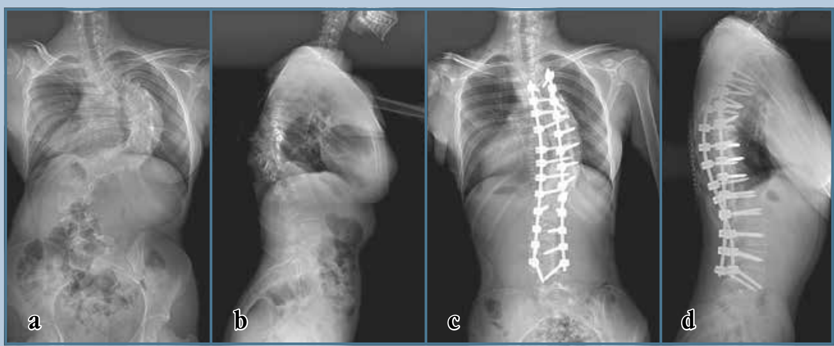

Fig. 2
Radiographs of 15-year-old patient Ts.: **a** – preoperative primary curve 118°, lumbar counter-curvature 72°; **b** – thoracic kyphosis 57°, lumbar lordosis 72°; **c** – postoperative primary curve 47°, lumbar counter-curvature 17°; **d** – thoracic kyphosis 38°, lumbar lordosis 42°

in a significant corrective effect. In both patients, neither hemodynamic disturbances nor alterations in skin temperature in the lower extremities were observed intraoperatively, but significant reduction in MEP amplitude was revealed. The fact that the second patient did not undergo mobilizing discectomy (the deformity was regarded as sufficiently mobile) can be classified as a difference. The dynamics of reduction of motor-evoked potentials were also different: the first patient showed gradual dynamics during the entire surgery, while the second one showed an abrupt elimination of the dynamics at the stage when the second rod was placed. In both cases, the surgeons were caught in a dilemma: whether they should continue the surgery while being guided by the skin thermometry data or immediately stop the corrective manipulations and remove the metal implant. After an urgent discussion, a decision was made to continue and complete the surgery. In both cases, this decision was justified.

We were governed by the fact that skin thermometry has been used more than 400 times and neither false-positive nor false-negative results have ever been reported. We are fully aware of the fact that none of the methods of intra-operative monitoring of the spinal cord function can be characterized by 100% reliability. However, judging from the findings we believe that the protocol of intraoperative monitoring should be supplemented with skin thermometry, in addition to recording SSEPs, MEPs, and performing the Wake-up test (in the cases reported in this article, SSEPs were not recorded in patients due to technical reasons). Today, thorough preoperative examination combined with integrated intraoperative monitoring of the spinal cord function is the optimal method for prevention and the earliest possible diagnosis of neurological disorders in patients with spine deformities.

We believe that including the skin thermometry method into this combination is justified. As for the reasons for amplitude reduction and disappearance of MEPs in the reported cases, we hold no convincing data for analysis and tend to classify these results as false-positive ones.

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