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NEUROLOGICAL CONTROL AND MONITORING IN SURGICAL CORRECTION OF SEVERE FORMS OF SCOLIOTIC DISEASE

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ABSTRACT

In this article searched usage of preoperative neurological control and monitoring. Carried out analysis of the problem of neurological complications during elective surgery of severe scoliotic disease forms.

Key words: Scoliosis, surgery, neuromonitoring, complications, children and adolescent.

INTRODUCTION

Neurological complications in the structure of complications associated with the treatment of severe forms of scoliosis deserve the greatest attention, since the frequency of their occurrence is the main indicator of the safety of elective surgery. Such complications are more common during corrective vertebrectomies and are a consequence of direct or (primary) or indirect (secondary) effects on the spinal cord and its membranes with impaired function of the former [1,3,8,27]. Large-scale studies of databases show that neurological deficit was most often recorded in the treatment of severe forms of scoliosis with VCR in 6.3%-8% of cases, while SPO accounts for 1.1% and only in 0.9% of cases is recorded in the absence of the first two interventions in the treatment complex [2,32, 27, 5]. The greatest risks of neurological complications are present if the value of scoliosis exceeds 100°, there is pronounced kyphosis, initial neurological symptoms, or the presence of vertebral dysplasia [16, 12, 18, 26, 17], while the incidence of iatrogenic inferior paraplegia ranges from 0.1% to -1.0% [7, 13]. Despite the significant experience of surgeon vertebrologists, neurological disorders of this type are recorded 41% more often in revision interventions than in primary ones, with a dominant number of complications in patients with revision operations ($p<0.001$) and the use of corrective vertebrotomies ($p<0.01$) [24]. It should be noted that the frequency of paraplegia was recorded 2 times more often with implants than without them (1.15% and 0.52%, respectively), while in 9.6% of cases of spinal cord injury there was no recovery of the latter's function [27].

Given the importance of the problem of neurological complications for elective surgery of scoliosis and its severe forms, in particular, the use of perioperative neurological control and monitoring is a prerequisite for treatment.

Stagnara's "wake-up-test" as a means of intraoperative control of motor function and spinal cord was proposed as early as 1973 by anesthesiologist Vauzelle et al. as a "patient walking during surgery", however, to this day the test is considered the "gold standard" in scoliosis surgery. The test assesses the functional integrity of the entire motor system and is divided into two phases: preoperative and intraoperative. The preoperative phase consists in the formation of the patient's belief that he/she will be required to move his/her limbs when waking up during surgery. In the second phase, during the operation, the anesthesiologist reduces the dosage of anesthesia and the effect of muscle relaxants, awakens the patient and requires movements of the upper and lower extremities. If the paraplegia test is positive, then a strategy is initiated to treat the neurological complication and, first of all, to reduce the magnitude of the achieved correction [22, 28]. It should be noted that repeating the test is not always feasible as the test time is limited due to the risk of inadequate anesthesia of the patient. In addition, despite its high reliability, the test is sometimes unable to detect spinal cord injuries. The use of the test is also limited in cases where the patient is initially unable to move the limbs, is unable to follow commands, or does not wake up. In most cases, a wake-up test is performed at the end of the correction and does not provide information about the condition of the sensitive area. In addition, when the level of anesthesia decreases, the patient may become agitated, extubated or fall off the table, and there are also contraindications for the use of the test in young children, with mental disorders, hearing loss and in the case of a language barrier. [28].

The clonus test is used to detect spinal cord injury in the presence of upper motor neuron problem and spinal cord shock [22]. The test is based on the detection of a clonus (such as the foot or patella) produced by the stretch reflex. Normally, central inhibition protects against the manifestation of clonus, but if it is not present, then clonus can be induced. It should be remembered that in the operating room, when leaving general anesthesia, clonus is induced, since anesthesia reduces cortical inhibition. If the spinal cord is damaged during surgery, the patient goes through a period of spinal shock, flaccid paralysis, and therefore it becomes impossible to induce clonus, even during the recovery from anesthesia. Later, spinal shock stops, the patient develops spastic paraplegia and it becomes possible to induce clonus again. Thus, there is a very short period of time for the evaluation of the clonus test after the end of the operation, only a few minutes, when the anesthetics and relaxants wear off and the patient's spontaneous breathing is restored. The absence of clonus may indicate spinal cord injury, but it may also indicate that the level of anesthesia is too high to provide cortical inhibition. Therefore, due to its low reliability, the clonus test has always been considered an auxiliary tool in determining spinal cord injuries [22].

Somatosensory evoked potentials (SEP) and motor evoked potentials (MVP) are a prerequisite for all surgical interventions on the spine, and they play a leading role in the complex of surgical treatment of scoliosis [10]. The use of the SEP technique to monitor spinal cord function was first described by Nash C.L. et al. in 1977, which, by stimulating the peripheral nerve of a mixed type, caused SEP, recording responses cranially and caudally from the site of surgical intervention repeatedly, repeatedly during surgery, and their amplitude

(altitude) and latency (transit time) were compared with baseline preoperative parameters [20]. Recordings of CVPs provide information regarding the function of the peripheral nerve, which is stimulated by transmitting a signal along the sensory tracts of the spinal cord, brainstem to the somatosensory cortex and is not a means of choice when it is necessary to obtain data on the functioning of motor tracts. To induce SEP, stimuli are used in the form of a square pulse of 200–300 microseconds and a frequency of 4.1–4.7 per 1 second. In SEP, the intensity of the stimuli varies, but is generally within 25 mA. Most researchers consider a decrease in the amplitude of the SEP by more than 50% and an increase in latency of 10% or more compared to the baseline values to be critical. [6].

There are many non-surgical factors that alter the signal of the MVP, of which the most important are anesthetics, mean blood pressure, and temperature. [30]. Anesthesiologists are forced to avoid inhaled substances and use intravenous drugs to produce an adequate level of sedation, with muscle relaxants having no significant effect on the SEP even when recorded at the level of complete or near-complete muscle relaxation. It has been observed that only at a blood pressure level above 60 mm Hg. usually there are no significant changes in the SEP [7]. According to some data, the reliability of the test is 72%-98.6% [24]. Registration of MVP can give both false-negative and false-positive results [11, 25, 9, 6] It was revealed that in the presence of initially present neurological symptoms, SIPS demonstrated a low reliability of 72% at low amplitude, compared to neurologically intact patients, and in 16% of their patients it was not possible to record SSV. However, multi-channel recording of SEP at the same time as fiberboard can increase efficiency by up to 96%-98.5%. [4, 10].

Multimodal neuromonitoring involves the use of a combination of SSEP and MDF, in which surgeons can obtain accurate information in real time regarding the function of both the sensory and motor tracts of the spinal cord, while both the motor cortex and the spinal cord are stimulated to obtain DVD [10]. Such neuromonitoring makes it possible to identify and inform surgeons during the course of surgery about an already occurring reversible or irreversible impairment of the conductive cord of the SM function, or on the restoration/improvement of the impaired conductive function of the SM, in response to the surgical effects performed. The criteria for a negative change in the conduction function of SM are a 50% decrease in sensory and motor responses in amplitude combined with a 10% increase in latency in relation to their initial intraoperative and/or preoperative values, which is the basis for giving a negative warning prognostic signal. Restoration or improvement of the characteristics of the above answers in relation to the initial ones is the basis for giving a positive prognostic signal, and is regarded as the elimination of a factor that provokes a violation or deterioration of the conductive function of SM [29, 10]. This method is universally recognized by the world surgical community and is a prerequisite for supporting all surgical interventions on the spine and spinal cord. Multimodal intraoperative neuromonitoring of SM has been clinically proven to be a highly effective (92.3%) and highly specific (98.5%) means of intraoperative neurophysiological control. [31, 15, 19, 10]. It reliably reduces the frequency of intraoperative neurological complications, making it possible to objectively assess the state of many neuronal structures in patients under anesthesia with lost consciousness, makes it possible to reduce the time for making an emergency decision to change the surgical plan, increasing the patient's chances of a favorable outcome of surgical treatment in the event of a complication [19, 10, 31, 23].

Among the limitations and disadvantages of the method, it is possible to single out the fact that the involuntary sphere of activity of the spinal cord is assessed, and specialists have no idea about the degree of voluntary control over the sensory and motor spheres, which, in fact, is possible only in a state of clear consciousness of the patient. In this regard, the "Staganara awakening test" along with the postoperative physical neurological examination are still an indispensable means of final complete control of the patient's neurological function after surgery. According to neurophysiologists, the use of "short-acting" muscle relaxants and special types of total anesthesia do not completely exclude possible errors in diagnosis and can cause the registration of both false-positive and false-negative signals of multimodal monitoring of the spinal cord. It is also known that the method is ineffective in patients with neurologically complicated scoliotic deformities [10].

Numerous publications show that to date there is no reliable data in the literature on the prevalence of severe scoliosis, since the main criteria have not been defined and clear boundaries have not been established for distinguishing severe forms of scoliosis from non-severe ones, as well as the principles and criteria for structural division within the category of severe forms of scoliosis have not been established, which does not allow for a reasonable differentiated approach when choosing surgical strategies in the complex treatment of complex pathology. High treatment efficacy, 61%-87% correction of severe scolioic curvatures, is associated with an equally high frequency of all kinds of complications, among which halotraction and VCR alone may account for 32-50% and 32%-59% of such cases, respectively, with a 12.3% reoperation rate [32, 11]. Neurological complications are recorded in 6.3%-8% of cases, with the incidence of irreversible paraplegia of 0.1%, -1.0% [32, 27, 5], which necessitates additional hardware neuromonitoring. The critical level of safety observed in the surgical treatment of severe forms of scoliosis is due not only to the severity of the condition, but also to the significant volume, complexity and trauma of the surgical strategies used, which becomes the main reason for the significant (7-12 hours) duration of operations, massive bleeding in 22% of cases and the loss of 6%-316% of the BCC with the need for blood transfusions in 23%-100% of patients. All this requires the urgent attraction of additional resources, causing a manifold increase in hospital costs.

Thus, the technological, anatomical, functional and economic expansiveness of the strategies used puts the surgical treatment of severe forms of scoliosis not only in the category of inaccessible, but also not fully justified types of surgical care. Today, the tasks of forming a differentiated approach in the complex of treatment of severe scoliosis and improving the use of less expansive, but not inferior in effectiveness strategies of staged correction using temporary (preliminary) internal distraction.

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