

The Value of Intraoperative Neurophysiological Monitoring in Neurosurgery Operations

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ABSTRACT:

The value of intraoperative neurophysiological monitoring in neurosurgery operations

Any manipulation or resection procedures during surgery of neural system or its surrounding structures carries a high risk of causing damage to the neural tissue. Existing intraoperative imaging tools provide only information about anatomic situation. Because of this insufficiency, both physicians and patients are displeased with additional neural deficits. Using intraoperative neurophysiological monitoring (IONM) that evaluate neurological function simultaneously is very important. It is also used in other surgical operations. In our article, we report importance and advantages of IONM in neurosurgical operations.

Keywords: Evoked potentials, motor pathways, neurophysiology, noromonitoring, sensory pathways

ÖZET:

Nöroşirürji ameliyatlarında intraoperatif nörofizyolojik monitörizasyonun yeri ve önemi

Sinir sistemi ya da çevre yapıların cerrahi girişimlerinde uygulanacak her türlü manipülasyon ve rezeksiyon girişimlerinin nöral dokuya zarar verme riski yüksektir. Mevcut intraoperatif görüntüleme araçları ancak anatomik durum hakkında bilgi vermektedir. Bu araçların nöral dokunun fonksiyonu hakkında bilgi verememesi hem hekimlerin hem de hastaların beklentilerini karşılayamamaktadır ve postoperatif dönemlerde ek nörolojik hasarlar görülebilmektedir. Nörofizyolojik işlevselliği eş zamanlı değerlendirmesi açısından intraoperatif nörofizyolojik monitörizasyon (İONM) kullanımı önem arz etmektedir. Diğer cerrahi branşlarda da kullanılmaktadır. Bu derlememizde İONM kullanımının nöroşirürjideki önemi ve avantajlarından bahsedeceğiz.

Anahtar kelimeler: Uyarılmış potansiyeller, motor yollar, nörofizyoloji, nöromonitörizasyon, duyuusal yollar

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INTRODUCTION

After the use of electrophysiological examinations as a diagnostic tool, monitoring of the neural functions of the patient during surgery came to mind. Penfield (1) worked on the somatosensory system monitoring in the 1930s. In 1950s, it was reported that epileptic foci could be determined by direct stimulation. At the end of the 1960s, the use of the IONM was initiated by facial nerve monitoring in vestibular schwannoma surgery, and became

widespread in most centers in the 1980s (2). Intraoperative monitoring of spine and spinal cord surgery began with a "wake-up test". Vazuella and Stagnara (3) reported in 1973 that with this test, the patient could be awakened and examined during the surgery to learn about spinal functioning. However, the wake-up test shows only the final state of the neural tissue, which is unable to give information about the stage of a neural injury. For example, neurological deficit may develop during screw placement or deformed spine manipulation in spinal

surgery. Because of these disadvantages, surgeons have sought another method. The use of IONM in spinal surgery has been attributed to the recording of somatosensory evoked potentials (SEPs) in scoliosis surgery in the 1970s. The sensory pathways can be followed with SEP starting from the peripheral nerve and leading to the dorsal and lateral parts of the cord, but the motor functioning cannot be assessed. In addition, in case of any neurological damage on SEP data, it has been reported that there may be a 4-30 min. delay and motor pathways should be monitored due to these deficiencies (4). Motor evoked potentials (MEP) provide information about motor pathways located in the ventral part of the spinal cord. MEP and SEP show the data obtained with a stimulus, continuous EMG (free-run EMG) method is added to these studies to continuously monitor the spine. Sensitivity and specificity have been increased to 90-100% with all three modalities. Neurophysiology education was added to a training program developed with a certification and qualification diploma in the United States in the 1990s. The IONM performed by the surgeon, anesthetist, neurophysiologist has a specificity of 96-100%. In practice, however, errors such as false negativities and false positivities can be seen. False negativity was found as 0.067% in multicenter and retrospective studies. While false positivities are at higher rates, false negativity may lead to permanent damage. Neurological damage was reported at 0.6-1% of spine surgeries without IONM, and this ratio was almost 10 times as false negativity. The cost of care for patients with neurological permanent damage according to the US is detected as 64000-102000 dollars/year (5). The size of the social and economic degradation that a paraplegic or tetraplegic patient will cause in our country is much more than the cost of IONM implementation.

Somatosensory Evoked Potentials (SEP)

The potentials obtained from cerebral cortex due to environmental stimuli are called sensory evoked potentials. Visual evoked potentials (VEP) and brainstem evoked potentials (BSEP) are also within the sensory evoked potentials group. If the peripheral

nerves and dermatomal receptors are stimulated, the potential obtained is called SEP. With SEP, only the results of the dorsal column functions are obtained (6,7). With dorsal column damage; touching, vibration, unconscious proprioception and positional senses are affected. The median nerve or ulnar nerve is preferred in the wrist when monitoring the upper cervical region sensory area of the spinal cord or the somatosensory pathways of the brainstem. The median nerve originates from the dorsal roots of C6-8 and T1, and ulnar nerve originates from the dorsal roots of C8, T1. In spinal surgery under C8, posterior tibial spinal nerve at the ankle and peroneal nerve at the knee level are stimulated for SEP monitoring of the lower extremity (Figure-1). Cervical vertebrae and scalp are used for recording. The electrodes which are placed on the scalp hair are placed at the cranial topography that matches the opposite side of the stimulated nerve of the arm or the the leg (8).

Motor Evoked Potentials (MEP)

Since the use of MEP can detect isolated corticospinal tract injuries and ischemias involving the anterior column, it is effective in protecting the structural and functional integrity of motor tracts (7). MEP is the recording of motor potentials from distal spinal cord or related muscle groups. Because it can respond to fast stimuli, it gives rapid feedback to the surgeon and provides great convenience. It provides great convenience especially for cervical and thoracic procedures (7). For MEP, usually abductor pollicis brevis is used in the upper extremity and tibialis anterior and abductor hallucis muscles are used in the lower extremity (Figure-1).

Brainstem Evoked Potentials (BSEP)

Besides cerebellopontin angle and posterior fossa surgeries, BSEP is a very useful method in craniocervical junction region and C1-C2 surgeries. Brainstem evoked potentials (BSEP) consist of seven potentials generated by a single acoustic stimulus. Electrodes are placed into the vertex scalp skin and behind the ear examined in the bone or ear drum (Figure-2). A stimulus is given with a click sound generated in one-



Figure-1: The view of electrodes attached for SEP and MEP records for IONM in the preoperative period in our case with cervical spondylotic myelopathy.

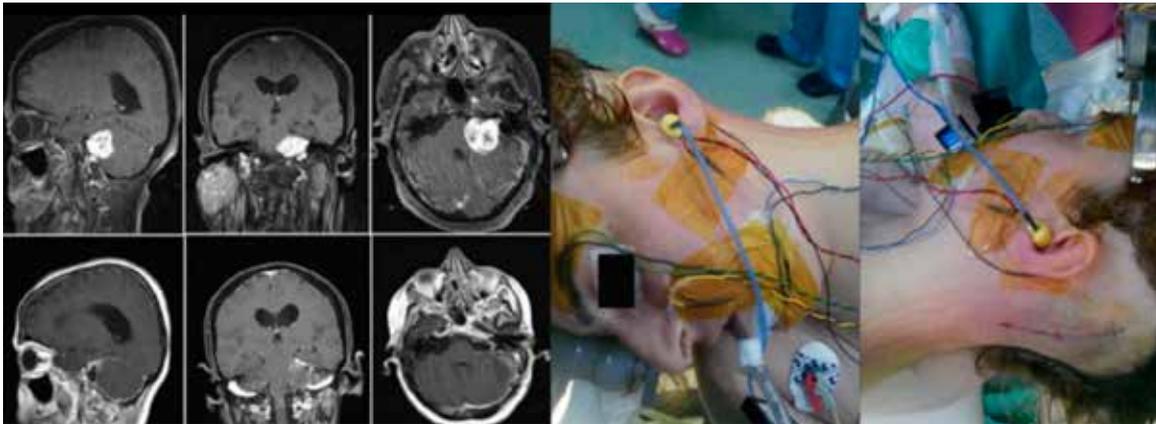


Figure-2: A 33-year-old female patient was admitted with low hearing in the left ear; BSEP and facial monitoring were performed in the peroperative period when preparations for vestibular schwannoma were being performed. Tumor resection was performed totally.

sided ear. The first response represents the acoustic nerve wave, the second dorsal cochlear nucleus, the third superior oliva, the fourth lateral lemniscus, and the fifth, ipsilateral auditory activation waves passing through the inferior colliculus. The sixth rostral mesencephalon or caudal thalamus or thalamocortical projection represents the seventh wave hearing cortex (9). Lower cranial nerve IONM and BSEP can be performed in brainstem, craniocervical junction and upper cervical region surgeries.

Visual Evoked Potentials (VEP)

VEP can be used during operations such as pituitary tumors including optic nerve or tractus optics, cavernous sinus tumors and aneurysms of the

region. By giving a flash stimulus to the eye, the occipital visual field is attempted to be stimulated, but it is more difficult and less used than in other IONM applications. Because of anesthesia, only flash stimuli are used, which is not always sufficient for VEP recording (10).

Measurement of Local Stimulus and Selective Muscle Responses with Probe

It is also possible to give and record local stimuli using weak current intensities with probe, if we want to know and maintain the location and type of neural tissue in the periphery or head. Thus, motor cortex mapping, differentiation of cranial nerves, or preservation of spinal structures can be achieved. It

is possible to identify proximity and tissue by changing the stimulus type (monopolar, bipolar, anodal, cathodal), severity and duration.

OPERATIONS IN NEUROSURGERY IN WHICH INTRAOPERATIVE NEUROMONITORIZATION IS USED SPECIFICALLY

Intracranial Aneurysms

There is always a risk of ischemia in the surgical treatment of aneurysms. IONM can be used to reduce this risk. In posterior circulation aneurysms, BSEP and SEP can be recorded simultaneously and

information about specific pathways in the brainstem and sensory cortex can be provided. Sensory Evoked Potentials should be recorded with median and tibial nerve stimulations in anterior circulation aneurysms. Findings of ischemia resulting in impaired blood flow during the procedure can give us information about midline and lateral sensory cortical functions. Bihemispherical EEG recording can also be performed during the procedure (11).

Microvascular Decompression Techniques

Recordings can be done with BSEP and related cranial nerve EMG routinely in surgical treatments of

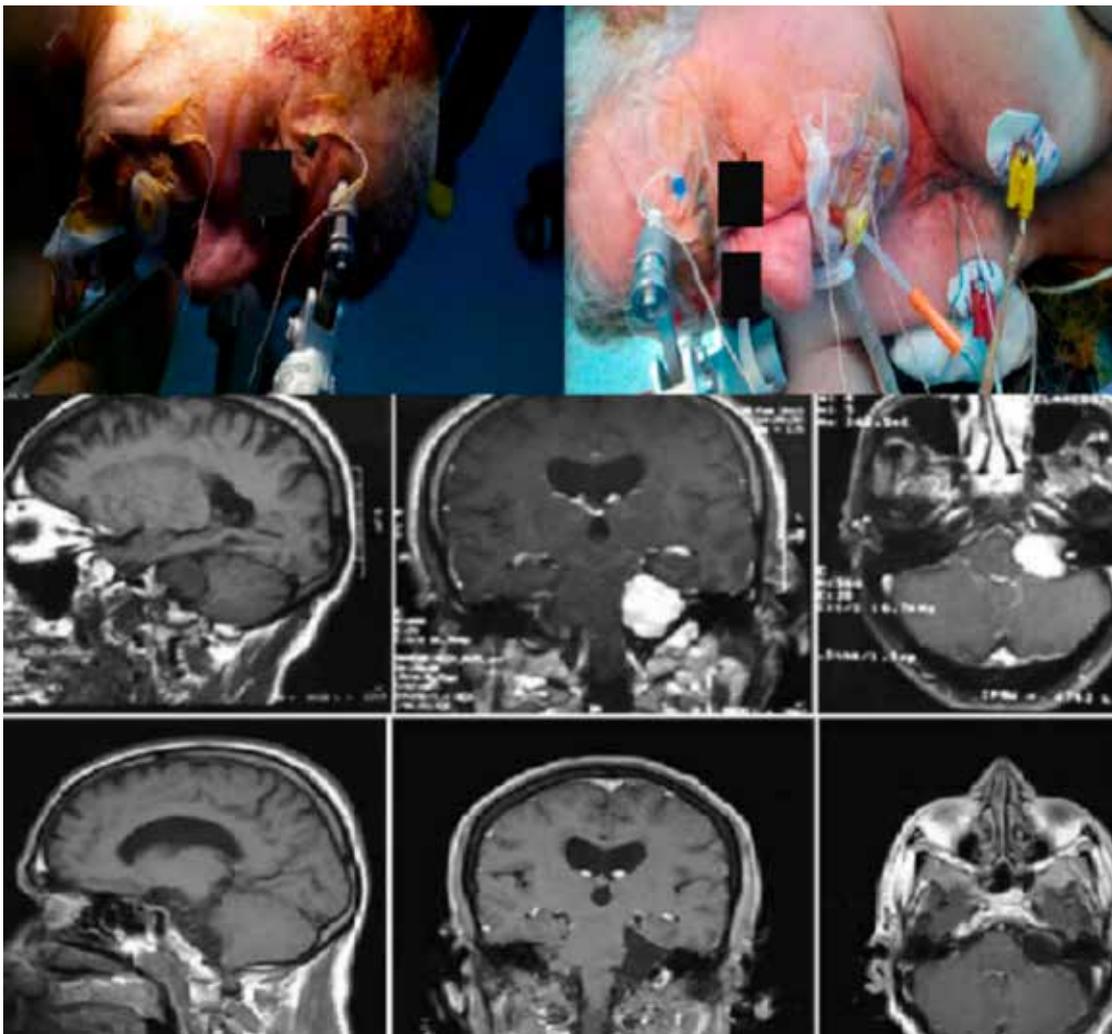


Figure-3: A corner tumor detected in a 64-year-old male patient and appearance of the facial nerve EMG electrodes applied for IONM. In the postoperative period, the hearing and facial nerve functions of the patient were normal and the tumor was totally excised.

neurovascular compression syndromes (in which 5, 7, 8, 9, 10, 11th cranial nerves are affected) (Figure-2). The eighth cranial nerve is more sensitive to manipulation than other cranial nerves in cerebellopontin region surgeries. The effectiveness of BSEP in protecting hearing functions is proven by its ability to demonstrate hearing functions.

Vestibular Schwannoma

In vestibular Schwannoma cases, cochlear nerve and facial nerve injuries are more likely to occur due to their proximity to the tumor. Due to the easy affectiveness of both cranial nerves from manipulations makes the surgical procedure difficult. Especially the facial nerve can be hidden due to the tumor tissue and it may be difficult to find its localization. Hearing loss and peripheral facial paralysis may be seen in patients following an unsuccessful cerebellopontin angle tumor surgery. The quality of life of the patient with particularly facial nerve paralysis is considerably reduced. Because of these reasons, BSEP and facial nerve EMG should be used peroperatively in the surgeries of this region today (Figure-3). The morbidity that may occur in surgery without IONM can be evaluated as malpractice. In our own clinic, we absolutely apply IONM in these type of cases.

Trigeminal Neuralgia

Vascular compression occurs most often in the proximal portion of the entrance of the root, near the pons, by the superior cerebellar artery. During decompression surgery, BSEP is performed for the 5th cranial nerve localization and function, and trigeminal nerve EMG is performed using subdermal electrodes over the masseter muscle.

Hemifacial Spasm

It is often caused by compression of the posterior inferior cerebellar artery in the root entrance area of the facial nerve. The facial nerve EMG is useful in showing the action potentials of the 7th nerve throughout its branches. Successful treatment may depend on the correction of facial nerve pressure

and the prevention of lateral spread. These results were verified by showing the presence of normal-evoked potentials in the orbicularis oculi and indirect discharges in the mentalis muscle by stimulation of the zygomatic branch with intraoperative facial nerve EMG (12) (Figure-2,3). Unlike other applications, the presence of abnormal discharges is also indicative of decompression adequacy here.

Stimulation of Pedicle Screws

The bone impedance is high; so, high stimulation is needed to stimulate the nerve near. A pedicle screw that led to bone fracture; nerve root stimulation is obtained by slight stimulation of the screw and records are obtained (?). Stimulation is performed with the electrode in the hands of the neurosurgeon (8). Instrumentation is either improper or there is a bone perforation if it is provoked with stimulation at and below 6mA (13).



Figure-4: IONM is routinely used in our clinic for cauda equina syndrome. Incision line, SEP, MEP and especially the MEP electrodes to be applied for anal sphincter in our case are seen.



Figure-5: Placement of electrodes for upper and lower extremity SEP and MEP records in the presence of intramedullary spinal cord tumor.

Cauda Equina Lesions

The follow-up and stimulation of neural tissue with EMG in surgical treatment of cauda equina lesions is essential for the identification of neural tissue. SEP and MEP must be used together (Figure-4). Neural tissue identification can be achieved with stimulation with the probe in the surgeon's hand. Pudental SEP, bulbocavernous reflex monitoring and anal sphincter muscle for MEP are also preferred in tethered spinal cord surgery (15) (Figure-4). Thus, intraoperative information about the urogenital and sphincter functions of the patient can be achieved.

Intramedullary Spinal Cord Tumors

The main purpose of the resection is to remove the

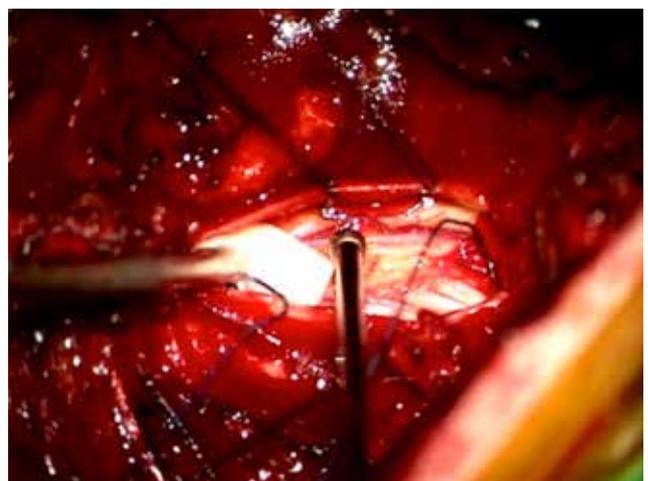


Figure-6: The view of direct nerve stimulation with monopolar probe used peroperatively in the same case with intramedullary spinal cord tumor.

tumor completely or subtotally without any damage the neural tissue. The most frequent injury in this surgery occurs during myelotomy. Even if SEP alone shows damage during dorsal myelotomy, using SEP alone in tumor operations is not enough, this surgery should be done using SEP and MEP together (Figure-5,6). Sala et al. reported that morbidity in cases that IONM has been performed in intramedullary tumor surgeries was less than in non-monitored cases and IONM contributed to showing the neurological damage (14).

Spinal Deformity Surgery

Neurological damage due to ischemia, compression, or traction can be detected in the early period with IONM and the situation can be reversed by stopping the procedure. In these surgeries, joint use of SEP and MEP is recommended. Traction and manipulation should be monitored immediately, and if a damage is suspected, it can be reversed to prevent damage.

CONCLUSION

IONM application provides a safe surgical procedure with high sensitivity rates. Conscious and educated staff are needed for the IONM process, which is becoming increasingly widespread and will be of future use due to medical or legal reasons. It is obvious that the cost of IONM application is small compared to the economic and social costs of neurologically impaired patients, when calculated annually. Particular use in peripheral nerve, spinal cord and spinal surgeries and cranial surgeries will help the patient and physician to smile in the postoperative period. The point that should be kept in mind is that the surgery will be performed by a surgeon, and the surgical procedure to be performed with confidence in the device without experience and sufficient knowledge can lead to more unintended consequences.

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