THE IMPORTANCE OF INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING IN THE SURGERY OF SUBTENTORIAL CEREBRAL PATHOLOGY

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Abstract: *Intraoperative neurophysiological monitoring in subtentorital pathology involves structures at risk such as cranial nerves, especially the facial nerve, trigeminal and vestibulocohlear nerve, but also the sensory and motor tracts passing through the cerebral trunk. Multimodal monitoring uses auditory, sensory and motor evoked potentials, as well as spontaneous electromyography and direct nerve stimulation of motor cranial nerves. The timely correction of changes in some parameters during these neurophysiological techniques allows for the avoidance of lesions of the nerve structures and thus, of the occurrence of postoperative neurological deficits.*

INTRODUCTION

Due to the high concentration of nerve structures and neurophysiological functions in the cerebral cortex, surgical morbidity is high compared to other structures of the central nervous system. During the resection of tumours in the cerebral trunk and its vicinity, a series of maneuvers can cause neurological damage: excessive electrocoagulation or traction on the nerves, nuclei or nerve pathways, improper or excessive use of retraction, inadequate coagulation or damage to penetrating vessels of the cerebral trunk. Intraoperative neurophysiological monitoring (IONM) aims at reducing complications and postoperative neurological morbidity by providing real-time information about nerve structure integrity, becoming one of the most valuable means of protecting patients during surgery. IONM warns the surgeon, in time, of possible lesions of the nerve structures so that corrective measures can be taken and irreversible neurological conditions can not occur. At the same time, IONM allows for more radical resections.(1)

METHODOLOGICAL ISSUES

We used 16-channel Xltek Protektor (Natus) apparatus for neurophysiological monitoring, using scalp corkscrew electrodes and subdermic needles electrodes for muscles and peripheral nerve stimulation. The device is part of the neurosurgical operating room equipment within the Polisano European Hospital in Sibiu.

IONM consists of mapping and monitoring techniques. The mapping technique allows the functional identification of nerve structures that may be difficult to identify from the anatomical point of view. An example is the identification of safe entry points on the IV ventricle by locating the cranial nerve nuclei. Mapping can also identify cranial nerves that are embedded in tumour structures, such as the location of the facial nerve in tumour surgery at the cerebello-pontine angle**.**

To ensure the functional integrity of the nerve structures, monitoring the evoked potentials and electromyography should be used.

Auditory evoked potentials (AEP)

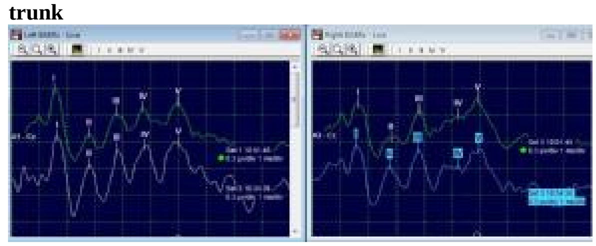
AEPs are obtained by transient acoustic stimulation in the form of clicks of an intensity of 90-100 dB. The stimuli are grouped in 100-ms trains and a 60-70 dB masking background noise is emitted in the contralateral ear. The polarity of the clicks will be alternating in order to reduce the stimulation artifacts. For the intraoperative neuromonitoring of AEP, silicone, cylindrical auditory inserts are used that can be attached to the external auditory canal and covered with waterproof adhesive tape to prevent fluid penetration.

Hearing inserts are connected to a transducer via flexible tubes. Propagation of the acoustic signal through these tubes can prolong AEP latencies by approximately 0.5-1.0 ms. Acoustic stimulation is done at a frequency of 11-20 Hz, the duration of the stimulus being of 100-200 ms, each ear being stimulated separately.

The AEP is recorded using a monopolar corkscrew electrode inserted in the scalp in the Cz position and some needles electrodes at the level of the ear lobes or mastoids. It is about the assembly of the Cz-A1 / A2 or Cz-Mi / Mc.

The criteria for the interpretation of intraoperative AEP modifications are based on the examination of amplitudes and latencies of waves I, III and V. Warning criteria are considered amplitude lowering by more than 50% or prolongation of latency of the wavelength V or I-V intervals by more than 1 ms. An alternative criterion would be the prolongation of V wavelength latency by more than 10% from baseline (figure no. 1). Amplitude changes are more frequent and occur earlier than latencies.(2)

Figure no. 1. Auditory evoked potentials of the cerebral trunk



Dysfunction or injury to the auditory pathways may be caused by a series of surgical maneuvers such as direct compression or direct traction of the auditory nerve in the cerebello-pontine angle surgery, thermal injury by

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electrocoagulation or vascular compressions in the vicinity of the cochlea, auditory nerve, or cerebral cortex. Ultrasound aspiratation in the cerebral cortex may also affect auditory pathways.

Motor evoked potentials (MEP)

MEPs are useful in monitoring the integrity of motor pathways in the brain stem located at the level of cerebral peduncles, bridge, and bulbar pyramids. The most common technique for obtaining MEP is multipulse stimulation in short, transcranial trains, which ensure the activation of the motor cortex. This technique exceeds the effect of anesthesia, allowing the MEP to be obtained under general anesthesia directly from the limb muscles.(3)

Transcranial electrical stimulation uses corkscrew electrodes inserted at scalp level, providing very low impedance and being well fixed intraoperatively. Short trains of 5 or 7 rectangular stimuli with a duration of 0.5 ms and an interstimulus interval (ISI) of 4 ms are used. The stimuli are applied at a rate of 1-2 Hz through the electrodes located at C1 and C2 motor points with C1/C2 stimulation for the right limbs, respectively C2/C1 for the left limbs. For the lower limbs, the Cz-Cz + 6 cm can be used, where Cz is 1 cm ahead of the classic Cz. For the upper limbs, lateral stimulation points, C3/C4, C3/Cz or C4/Cz can be used, but they can produce wider movements of the patient, especially at higher intensities, and may also lead to deeper corticospinal tract activation at brain or even of brain stem level.(4)

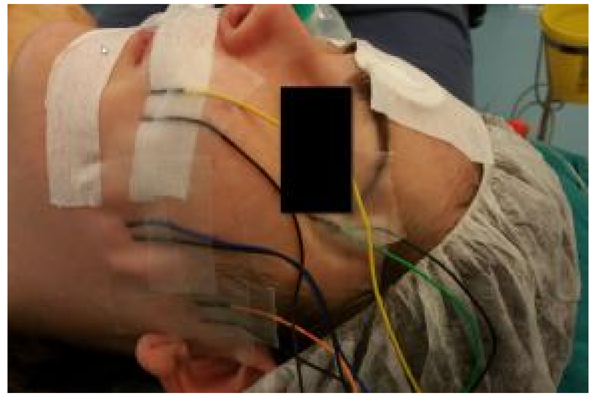
Transcranial electrical stimulation is a safe method and adverse events only have been reported anecdotally.(5) The stimulation intensity does not exceed 200 mA. Motor responses are recorded using the needle electrodes inserted into the limb muscles. The monitored muscles are generally the abductor policis brevis (APB) and the extensor digitorum comunis at the upper limbs, the anterior tibial AT and the abductor hallucis AH at the lower limbs. At the level of the brain stem, the corticospinal tract is concentrated in the ventral part of the brain and thus, a lesion thereof is unlikely to cause a selective muscular injury. That is why it is enough to monitor just one muscle from each member.

Electromyography (EMG)

The standard technique for monitoring cranial nerves is spontaneous electromyography taken from the muscles innervated by the cranial nerves.(6) One of the most monitored cranial nerves is the facial nerve. Electromyography of the facial nerve is achieved by inserting pair electrodes into the orbicularis oculi and orbicularis oris ipsilateral with the tumor. A ground electrode is attached to the scalp. This assembly helps covering the muscles that are representative of the major branches of the facial nerve (figure no. 2) The motor unit potentials are then monitored that can be grouped under the form of high frequency neurotonic, intermittent or continuous discharges caused by mechanical or metabolic stimulation of the nerve. The mechanical stimuli can be compressive, thermal, during manipulation, irrigation or stretching of the nerve. Metabolic changes occur during ischemic stress.(8) In order to provide real-time feedback, electromyographic graphs are associated with sounds that can be played on the speakers so that they can be heard by the surgeon, having special characteristics (figures no. 3 and 4).

Over time, variable criteria have been proposed to identify certain features of EMG that indicate nerve damage. It is assumed that an irritant activity occurs when the nerve is manipulated and stops when this manipulation stops, following a good prognosis of surgery. On the other hand, neuromyotonic discharges or high frequency trains that persist for a long time are representative of potential nerve lesions. Paradoxically, electric silence that might suggest that nerve integrity is not impaired could also be seen in its complete section.

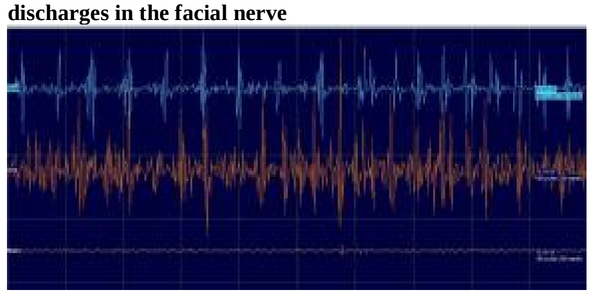
Figure no. 2. Montage for monitoring the facial, trigeminal and vestibulocohlear nerve



On the other hand, certain EMG irritant activity could also be determined by simple irrigation of the operator field with saline without correlation with the nerve lesion.

Figure no. 3. Peak spontaneous electrical discharge in the facial nerve

Figure no. 4. Spontaneous neurotonic electrical nerve discharges in the facial nerve

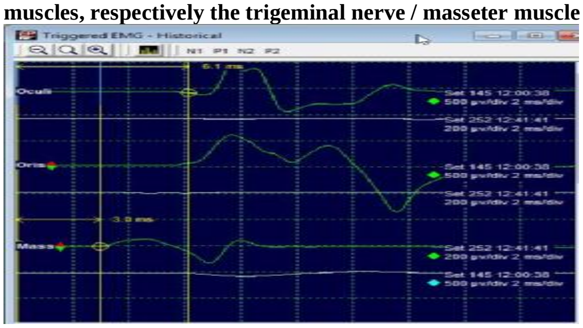


In addition to spontaneous electromyography, it is possible to directly stimulate the facial nerve in the operator field by means of a stimulator, a technique called direct nervous stimulation. This stimulation will generate a motor unit potential (MUP) recorded on the monitor screen. This technique will allow the neurosurgeon to identify and localize the facial nerve during tumour resection. It will also provide the surgical team that the nerve is integral, distally to the stimulus point (figure no. 5).

The stimulation is performed with a monopolar cathodal stimulator. The stimulator is connected to a constant voltage- current source that starts stimulating at an intensity of 0.05 mA in steps of 0.05 mA. The maximum stimulation intensity is 5 mA, above this intensity, the current can irradiate and stimulate other neighbouring nerves. The stimulation is done with a rectangular impulse with a duration of 0.05-0.1 ms.

An alternative method of stimulation is with the bipolar stimulator with the anode and the cathode separated by 1-20 mm. The benefit of this type of stimulation is the greater spatial specificity with lower intensity and less dispersion of the current, but with less sensitivity and high local shunt due to excess fluid in the operating field.(7) Besides identifying the facial nerve, the results of direct electrical stimulation after tumour resection are predictive of the postoperative state of the facial nerve. This is of immediate clinical importance in the case of reconstruction of the injured nerve.(9)

Figure no. 5. Motor unit potentials obtained by direct stimulation of the facial nerve/oculi and oris orbicular muscles, respectively the trigeminal nerve / masseter muscle



Sensory evoked potentials (SEPs)

SEPs appreciate the integrity of dorsal columns. SEPs are obtained by stimulating the median nerve and tibial nerve with a minimum intensity of 40 mA, a duration of 0.2 ms and a repetition rate of 4.3 Hz. SEPs recording is done at scalp level with electrodes disposed in Cz'-Fz assembly for feet and C3'/C4'-Cz' for hands. Like AEP, SEP has been used to monitor the cerebral cortex although, together, they can only evaluate 20% of the integrity of the troncular pathways.

However, SEPs are useful when talking about tumours at the cervicomedullary junction where the dorsal columns end at the level of the Goll and Burdach nuclei. SEPs are very sensitive to surgical manipulation, so their modification is not necessarily a criterion for giving up surgery. For pontine and mezencephalic lesions, SEPs have a low localization value but provide nonspecific information about brain stem status because a major impairment thereof will be expressed by SEP changes.(10)

When these warnings occur within IONM - a more than 50% decrease in MEP or SEP amplitude, elongation of V latency by more than 10% to AEP or SEP, there are at least three steps to take in order to recover these potentials. These measures are grouped under the acronym T.I.P.: Time/Irrigation/Pressure.(11) In other words, a pause should be taken during the operation, to irrigate the operating field with saline at the temperature of the body, possibly raising the blood pressure or locally applying Papaverine if signs of vasospasm occur.

RESULTS AND DISCUSSIONS

We performed IONM in the following cases of subtentorial pathology:

- 4 cases of microvascular decompression for trigeminal neuralgia (figure no. 6)
- Exophytic, pontine stem brain tumour,
- Extra-nevraxial tumour of posterior cerebral fossa (epidermoid cyst);
- Left cerebellar tumour;
- Acoustic nerve neurinoma.

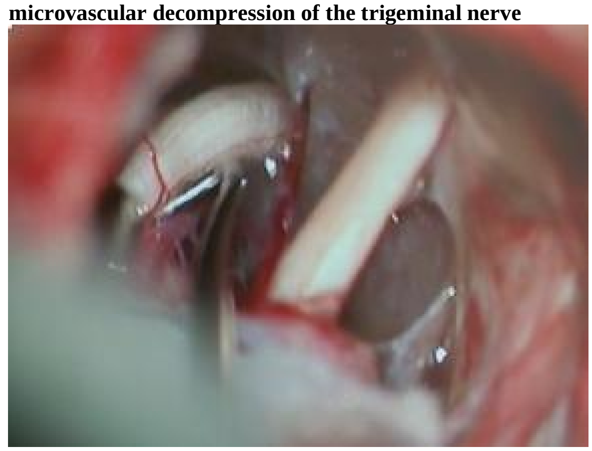
In the four cases of trigeminal neuralgia where surgery was performed by microvascular decompression, trigeminal nerves were monitored, with their motor component, which innervated the masseter muscle, the facial nerve through the orbicular muscles of the eyes and mouth, and the vestibulocohlear nerve with the help of the auditory evoked potentials. The motor nerves were monitored by spontaneous electromyography and identified by direct nervous stimulation. Spontaneous electrical activity has occurred, under the form of peaks, peak groups and trains, but they stopped after taking proper measures. There were no motor deficits in the facial and trigeminal nerves.

In one case of the above, there was an alteration of AEP in terms of prolonging the wavelength III by 0.8 ms, which persisted until the end of the intervention and which was followed postoperatively by a mild and reversible vertiginous syndrome without hearing loss.

In the case of excision of the acoustic nerve neurinoma, the facial nerve was identified by direct stimulation, but it could not be stimulated proximally to the tumour due to its size and consequently, after the tumour resection, the nerve did not respond to the stimulation anymore. No intraoperative neuromiotonic discharges were obtained. Postoperatively, the patient presented partial motor deficit in the facial nerve area and pre-existing hypoacusis, ipsilaterally to the tumour.

Cases of brain tumours, stem brain tumours and extranevraxial posterior cerebral tumours have been monitored with motor and sensory evoked potentials that have not undergone changes during surgery. Patients did not experience new motor or sensory deficits postoperatively.

Figure no. 6. Image from the operative field for microvascular decompression of the trigeminal nerve



CONCLUSIONS

Intraoperative neurophysiological monitoring is also useful in subtentorial pathology surgery where important nerve structures such as cranial nerves and ascending sensory pathways and descending motor pathways of the cerebral cortex are at risk.

Integrating these techniques into multimodal monitoring offers the best chance of detecting a brain lesion within a sufficient time to take corrective action to prevent or at least limit certain postoperative neurological deficits.

Even when there are no changes in the parameters used for monitoring, it gives the neurosurgeon greater confidence and allows a more radical resection within safety limits.

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