USEFULNESS OF MULTIMODAL INTRAOPERTIVE NEUROPHYSIOLOGIC MONITORING DURING DIFFERENT NEUROSURGICAL OPERATIONS

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بحث مقدم من الطبيب

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INTRODUCTION

Neurosurgical procedures for lesions placed in or close to eloquent areas carry increased risk of neurological deficits, such as dysarthria, aphonia, paralysis and paresthesia. Therefore, neurophysiological monitoring is essential for almost all operations in or around eloquent locations of the brain and spine. [1]

Intraoperative neurophysiological monitoring (IONM) is the use of electrophysiological methods to define eloquent neural structures and to monitor their functional integrity during the surgery and provide information to surgeon to prevent permanent neural injury due to surgical interventions. In most neurosurgical procedures, IONM is a valuable and beneficial method for monitoring the integrity of neural structures at risk. It provides simultaneous neural information throughout the surgery. [2]

Using different modalities of IONM can aid in neurological recovery and prevent damage . [3,4]

Somatosensory-evoked potentials (SSEPs) test the sensory pathways that ascend through the dorsal column of the spinal cord, so normal SSEPs does not exclude motor pathway injuries. Therefore, SSEPs are often supplemented with motor-evoked potentials (MEPs). [5]

Stimulating needle electrodes are placed at the wrist and ankle for the evaluation of the median and tibial nerves, respectively and SSEPs are recorded using electrodes over the scalp. A warning signal is generally issued when there is a 50% decrease in amplitude or 10% increase in latency compared with baseline values. [6]

SSEPs signal changes, however, are not always related to a postoperative neurological deficit. The specificity of SSEP during IONM was reported as 27%, whereas the sensitivity was 99%. [7] The use of SSEPs is advantageous because it does not provoke unwanted movement of the patient during surgery; and it is easily quantifiable. [8]

Transcranial Motor Evoked Potential **(**tcMEP) is recognized as the most sensitive technique compared with SSEP.[8] It monitors the corticospinal pathway and aids in early detection of neurological dysfunction. [9-11] Trans cranial electrical stimulation via electrodes placed on the scalp over the motor cortex area is usually employed for the generation of MEPs and hence stimulation of the corticospinal tract. A short train of 5-7 electrical pulse stimuli with high frequency are usually used because it can generate action potential more easily through the summation of the excitatory postsynaptic potentials. MEPs can be recorded over muscle (Tc-mMEP) or over the spinal cord (D and I waves). Of these, Tc-mMEP seems to be the most widely adopted approach because of the relative simplicity of generating and recording MEPs. [8]

MEP amplitude decrements >50% of baseline values were considered indicative of significant change, provided that the levels of neuromuscular blockade and general anesthesia were unchanged. [12] MEP can also detect hemodynamic changes like hypotension changes, positioning change and spinal cord or roots compression. Only few studies report the alarm criteria of MEP or SSEP for decompression surgeries. [13]

Propofol causes less suppression of MEP than inhalational agents. Consequently, propofol and opioid total intravenous anesthesia (TIVA) is widely recommended in intraoperative monitoring. [13] Deepening anesthesia and administering boluses reduces or obliterates muscle MEPs, whereas lightening anesthesia increases them. Stable anesthesia is desirable, but adjustments may be medically indicated and it is necessary to track them. Short acting neuromuscular

blockade is often used to aid intubation of the patient during induction of anesthesia. [13]

In addition, Free-running Electromyography (EMG) has been used as a real-time monitoring modality to complement SSEP and tcMEP. [8] It detects mechanical and/or metabolic irritation of the nerve. It can be recorded in the innervated muscles without electrical stimulation of the nerve. [8]

Two types of discharge, each with different clinical significance, can be observed using free-running EMG monitoring: tonic discharge and phasic discharge. Tonic discharge consists of repetitive and steady episodes of activity from grouped motor units that can last from several seconds to minutes; it can be observed in nerve ischemia due to traction, heat spread from electro cautery, or irrigation with saline. In contrast, phasic (burst) discharge is a short and relatively synchronous burst of motor unit potentials, which is mostly associated with blunt mechanical trauma. [8]

The old version of intraoperative assessment, wake-up test, might be occasionally carried out when traditional neurophysiologic monitoring is not available. In this procedure, the patient is awakened on the surgery table, with the wound still open and the patient intubated. Narcotics are used to relieve pain. When sufficiently awake, the patient is instructed loudly to move each extremity to detect if there is injury of spinal cord. Problems can occur if the patient is too confused to cooperate, or if the patient becomes agitated, he might move on the table, extubate himself, knock out intravenous lines, or cause other difficulties, Awakening of patient also may increase blood pressure of patient and cause excessive bleeding. [14]

Universally IONM is mandatory now in correction surgery for spinal deformities with high sensitivity and specify in detecting deficit. [15] IONM of MEP in deformity surgeries can be focused during the time of maximal

manipulation of neural elements, such as during screws insertion and correction. In contrast, during decompression for cervical myelopathy, the risk to the spinal cord and nerve roots exists throughout the entire decompression procedure and not during a defined short period. [9] Moreover, the risk may be present even before the procedure during positioning of the patient's neck during intubation. Despite that, the indications for monitoring in cervical decompression surgeries are still controversial. [3,16] Some advocate its use [9-11] while others argue against. [3,16]

To use only a single modality is not enough for a successful and efficient neuromonitoring in neurosurgery. It has been shown that multimodal monitoring has a high specificity and sensitivity in detecting postoperative neurological injury.[17] Therefore, it is suggested to use appropriate multimodal intraoperative neuromonitoring techniques for various surgeries to avoid any neurological damage.

AIM OF THE WORK

1. To assess the usefulness of applying appropriate different neuromonitoring modalities in various neurosurgical operations with high risks of neural injury
2. To enhance our clinical experience and technical skills on various neuromonitoring techniques.

SUBJECTS

Twenty five patients with different brain or spine lesions will be admitted to Neurosurgery Department in Alexandria Main university hospital and are scheduled to undergo surgery under Intraoperative neurophysiological monitoring. Multimodal neuromonitoring techniques such as Somatosensory-evoked potentials (SEP), transcranial electrical stimulation–motor-evoked potentials (TES-MEP) , Free-running, Triggered Electromyography (EMG) and electromyographic monitoring of different cranial nerves will be used during the operation.

Inclusion criteria:

All patients will meet the following inclusion criteria:

1) Adults > 18 years
2) Brain or spine lesion close to eloquent area indicated for neuromonitoring.
3) Magnetic Resonance Image (MRI) for the site of lesion reflecting neural injury risks.

Exclusion criteria:

1) presence of vascular clips, intracranial electrodes, pacemakers, other implanted bio-mechanical equipment, cortical lesions, skull defects, increased intracranial pressure, and history of epilepsy

METHODS

Preoperative assessment:

All patients will be subjected to the following:

1- Clinical Examination including history taking, symptoms & signs.

2- Complete neurological examination.

4- All patients will be consented for Intraoperative neurophysiological monitoring (IONM) as a part of the surgical informed consent process.

Intraoperative Procedures:

Anesthesia

Total intravenous anesthesia (TIVA protocol) will be used: Induction of anesthesia will be performed with fentanyl 1 μg/kg and propofol 2 mg/kg intravenous, followed by a short acting muscle relaxant such as succincyl choline to facilitate tracheal intubation. Anesthesia will be maintained with 50% oxygen in air and propofol infusion. The infusion starts at 12 mg/kg/h and then decreased gradually to 6–10 mg/kg/h. The infusion rate is then adjusted according to hemodynamic responses to maintain a mean arterial pressure (MAP) between 60 and 70 mmHg**.** [19]

Monitoring Technique

Multimodal IONM (MIONM) for different pathologies will include SSEP and TES-MEP for spinal and cranial operations and free-run, triggered EMG would be used for brainstem operations in which cranial nerves were at risk.

Monitoring Technique ISIS IOM Neuromonitoring System (Inomed, Emmendingen, Germany) will be used for MIONM procedure. Monitoring will be throughout the surgery.

Monitoring will be divided into 3 stages: pre baseline, baseline, and monitoring.

Pre baseline includes period from patient's arrival to the operation room to baseline recordings. It will take about 40 minutes long and allow us to check the system and signal. This time covers equilibration of the anesthetics and elimination of muscle relaxants used for induction, which cause variability in recorded signals. [20]

Baseline is the period just before the high-risk manipulation of surgeon. Baseline data will be recorded and used as reference in monitoring period during the rest of the surgery. [20]

Anesthesia will be maintained by total intravenous anesthesia. Muscle relaxants will be used only for intubation and then will not be administered again except in cases that will require monitoring, which does not include MEP and EMG. [21]

Transcranial Motor evoked potentials monitoring:

TcMEPs will be performed using transcranial stimulator over cortical motor area. The electrodes will be placed over the motor cortical regions at C3 and C4 (International 10-20 system of electrode placement)(Appendix I). The stimulation will be delivered with a train of 4-7 square wave pulses (75 μs duration) while maintaining the inter-stimulus interval (ISI) at 2 msec. Stimulation intensity will be started at 150 Volts and increased by 20 Volts increments until robust response is obtained from several muscles. [22]

The tcMEPs will be recorded by a pairs of needles inserted in target muscles. Target muscles in the upper extremity will be deltoid (axillary nerve, C5-C6), biceps (musculocutanouse nerve, C5-C6), triceps (radial nerve, C7), abductor pollicis brevis (APB) (C8-T1) and trapeziuses (C4) when needed if

the level is above C4. In the lower extremity, tibialis anterior (TA), abductor halluces (AH) and extensor digitorum brevis (EDB). [22]

Somatosensory evoked potential monitoring

SSEPs will be elicited by the stimulation of the posterior tibial nerve at the ankle and median nerve at the wrist region. The cortical potentials of SSEP will recorded from CP3 (2 cm behind C3) and CP4 (2 cm behind C4) in the upper extremities and CPz (2 cm behind CZ)/Fz in the lower extremities (depending on the 10–20 international electrode system). [23]

The stimulation will be delivered by alternating stimulation of the posterior tibial nerve or the median nerve sites using biphasic 200 μsec square wave pulses at a rate of 2.66/sec and intensity of 12-16 mA at median nerve & 40-60 mA at posterior tibial nerve. Each average consists of about 200 trials and with a band pass of 30–1000 Hz.[23]

Spontaneous Electromyography

free running EMG will be monitored from all the recording muscles of the upper and lower limbs involved in the surgical level.

Baseline readings will be obtained before skin incision. SSEP will be analyzed for latency and peak-to-peak amplitude and MEP will be analyzed for amplitude and threshold. Stimulation will be alternated between SSEP and MEP in continuous order while free running EMG will be performed throughout surgery. The surgical team will be immediately informed of any significant IONM changes. [24]

EMG Monitoring of Cranial Nerves

One pair of needle electrodes 1.5 cm apart from each other will be inserted to orbicularis oris and one pair to orbicularis oculi muscles for monitoring facial nerve functions. Another pair of needle electrodes will be inserted to masseter muscle for trigeminal nerve monitoring. For hypoglossal nerve monitoring , needle electrodes will be inserted to lateral site of tongue. For both glossopharyngeal and vagus nerves monitoring also needle electrodes will be placed to posterior wall of pharynx. Impedances of all electrodes should be below 2 kO. Direct electrical stimulation of nerves will be performed using bipolar hand probe to localize and find the trace of the nerve. Both free run EMG and triggered EMG of cranial nerves will be used.[25]

Post operative evaluation :

- Full clinical neurological examination to asses any superadded neurological deficit

ETHICS OF RESEARCH

Research on human or human products:

- ☐ Prospective study: Informed consent will be taken from patients. In case of incompetent patients the informed consent will be taken from the guardians.
- ☐ Retrospective study: Confidentiality of records will be considered
- ☐ DNA / genomic material: Informed consent for DNA / genomic test and for research will be taken from patients. No further tests will be carried out except with further approval of committee and patients. If the samples will travel outside Egypt the researcher will be responsible for transportation and security approval.
- ☐ All drugs used in the research are approved by the Egyptian Ministry of Health

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Research on animal:

- ☐ The animal species are appropriate for the test.
- ☐ After test, if the animal will suffer, it will be euthanized and properly disposed.
- ☐ After operation, it will have a proper postoperative care.

RESULTS

The results will be tabulated and analyzed according to the different findings.

DISCUSSION

Findings will be discussed in view of achievement of the aim of the study and will be compared with similar studies in literature.

APPENDIX I

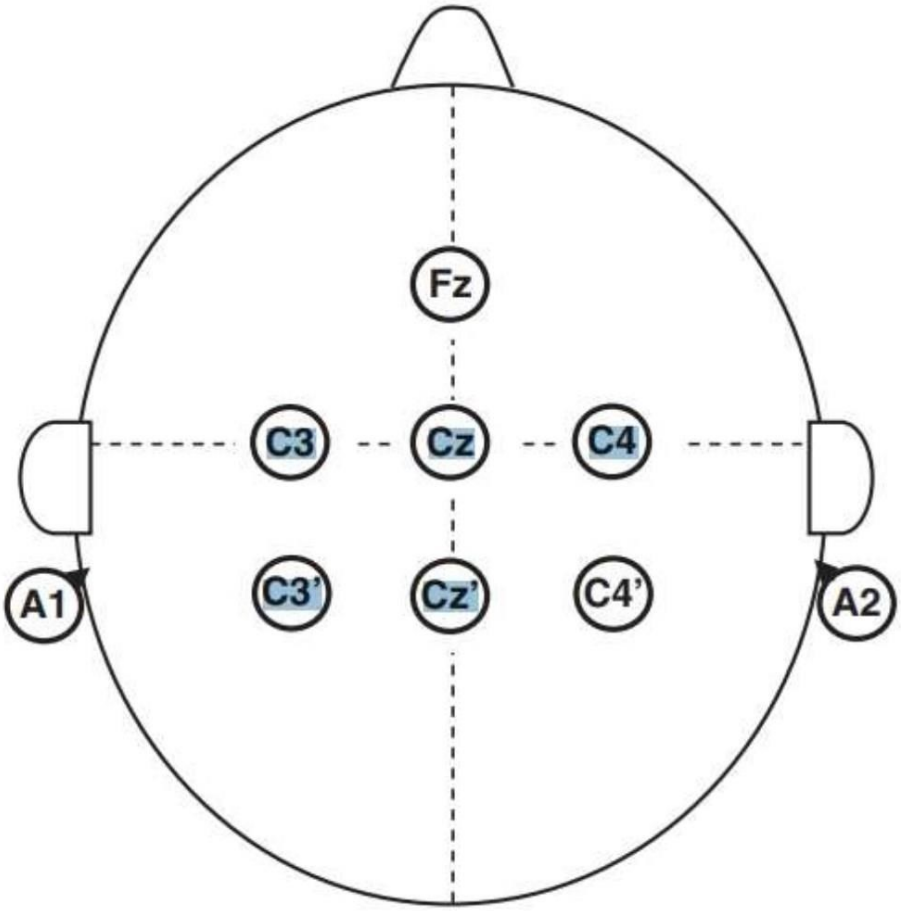

FIGURE 1. Electrode positions on scalp for somatosensory evoked potentials (SEP), motor-evoked potentials (MEP), and brainstem auditory–evoked potentials (BAEP) monitoring.[26]

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