Application of Intraoperative Neurophysiological Monitoring: New insights

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ABSTRACT

Various intraoperative neurophysiological monitoring (IONM) helps in assessing the integritry of neural pathways during the surgical treatment. IONM is an assistive tool to preserve the fuction of brain, brainstem, cranial nerve, spinal cord and peripheral nerves and a great assest for neurosurgeons. Different application of IONM includes: MEP, SSEP, ABR, VEP, BCR and AMR. Intraoperative neuromonitoring has become an integral part of the neurosurgery and is being routinely used in various operative cases. This paper discusses the application and benefit of IONM, with its role in delivering a high quality intra operative care to detect and prevent neurological deficits.

Keywords: Intraoperative; neurophysiological; monitoring.

INTRODUCTION

It is very important to predict postoperative neurological functions during surgical manipulations. The intraoperative neurophysiological monitoring (IONM) only can evaluate neural pathway directly during general anesthesia.[1,2] By utilizing the IONM, the surgeon can recognize risk of injury during the surgery. There are various methods of IONM such as MEP, SSEP, ABR, VEP, BCR, AMR etc.

IONM modalities

MEP: Motor evoked potentials

Intraoperative monitoring of MEPs has been reported to be useful for preventing postoperative motor dysfunction for aneurysmal surgery located in internal carotid artery (ICA) and middle cerebral artery (MCA) and resection of tumor near sensorimotor areas or corticospinal tract.[3–6] MEP monitoring can detect a pyramidal tract insult as a decrease of the amplitude of the waveform elicited by electrical stimulation.

Evalution neural pathway: corticospinal tract
Stimulation points: transcranial, transcortical, subcortical
Low cut filter: 2-50 Hz
High cut filter: 1-3 kHz
Recording points: spinal cord, extremity (compound muscle action potential
Stimulation method: electrical high frequency train 5 (duration 0.2 mS, interval 500 Hz)
Anesthesia: Total intravenous anesthesia (TIVA) without muscle relaxant
Averaging: Not necessary

SEPs: Somatosensory Evoked Potentials

SEPs consist of a series of waves that reflect sequential activation of neural structures along the somatosensory pathways.[7] The stimulation sites typically used for clinical diagnostic SEP studies are the median nerve at the wrist, the common peroneal nerve at the knee, and the posterior tibial nerve at the ankle. Somatosensory

evoked potentials (SSEPs) have been used as indicators of cerebral ischemia during CEA, although far less commonly than EEG. Somatosensory evoked potentials (SSEPs) primarily assess the integrity of the dorsal (sensory) pathways of the spinal cord. SSEP monitoring provides real-time examination of spinal tracts at risk during surgical manipulation of the spinal cord such as spinal tumor, pedicle screw surgery.

Evalution neural pathway: Sensory route (posterior column, medial lemniscus, thalamus, primary sensory cortex)
Stimulation points: median nerve in upper extremity, tibial nerve in the lower extremity
Bandpass filter: 1-20Hz 1.5KHz-3KHz
Recording points: The lower limb is recorded with Cp1, Cpz, Cp3 and reference Fz or A1,A2.
Upper limb is recorded with Cp3, Cp4 and Fz, A1, A2
Stimulation method: electrica less than 10 Hz
Anesthesia: No limitation
Averaging: 200 times

ABR: Auditory Brainstem Response

ABR is a test to measure the brain wave activity or to diagnose dysfunctions of the auditory pathways within the auditory nerve and brainstem that occurs in response to clicks or certain tones.[8] This is useful in the surgery of CP angle tumor such as vestibular schwannoma, MVD for hemifacial spasm and trigeminal neuralgia.

Evalution neural pathway: Hearing Function
Stimulation points: external auditory canal
Recording points: cochlear nerve, skull convexity (EEG)
Stimulation method: click sound stimulation, frequency less than 15 Hz
Anesthesia: No limitation
Averaging: 500 times

VEP: Visual Evoked Potential

In neurosurgical procedures that may cause visual impairment in the intraoperative period, the monitoring of flash VEP is clinically used to evaluate visual function.[9] Surgeries that pose a risk of visual impairment in the intraoperative period include neurosurgical procedures, particularly tumorectomy at the optic chiasm of pituitary adenomas, craniopharyngiomas, tuberculum sellae meningiomas, and other tumors; the removal of brain tumors from the optic pathway and structures in its vicinity such as the optic nerve, optic radiation, and occipital lobe; and internal carotid artery aneurysm clipping, which poses a risk of impeding blood flow to the ophthalmic artery.[9] Monitoring intraoperative flash visual evoked potentials (VEPs) assesses the functionality of the optic pathway from the retina to the visual cortical area, and allows visual impairment to be avoided or minimized.

radiation occipital lobe
Stimulation points: eyeball
Recording points: optic pathway, occipital (O1,O2, Oz)
Stimulation method: Flash light stimulation, duration: 20 to 40 mS, frequency 1 Hz
Anesthesia: TIVA
Averaging: 100 times

BCR: Bulbo-Cavernosus Reflex

BCR is a well-known somatic reflex that is useful for gaining information about the state of the sacral spinal cord segments.[10] When present, it is indicative of intact spinal reflex arcs (S2–S4 spinal segments) with afferent and efferent nerves through the pudendal nerve. BCR is of the greatest utility for the monitoring of sacral function in untethering surgery.[11] It is performed by electrically stimulating pudendal afferent fibers at the clitoris or penis using surface electrode and recording triggered EMG in external anal sphincter using subdermal needle electrode.

Evalution neural pathway: Sensory and motor sacral route and conus medullaris
Stimulation points: Penis or clitoris
Recording points: Anus EMG
Stimulation method: electrical high frequency train 5 (duration 0.2 mS, interval 250-500 Hz, 5 times)
Anesthesia: TIVA without muscle relaxant
Averaging: Not necessary

AMR: Abnormal muscle response

AMR, which is also called as lateral spread response, is used in the microvascular decompression (MVD) for hemifacial spasm.[12] Complete disappearance of AMR after MVD from root exit zone means postoperative disappearance of the hemifacial spasm. However, the persistence of the AMR does not mean incomplete MVD.

Evalution neural pathway: Facial nerve and facial nucleus in hemifacial spasm
Stimulation points: facial nerve
Recording points: facial EMG
Stimulation method: electrical single stimulation
Anesthesia: No limitation
Averaging: Not necessary

CONCLUSION

The intraoperative neurophysiological monitoring is very important tool to reduce neurological morbidity associated with surgeries.

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