**Intraoperative Neurophysiological Monitoring Methods; MEPs, D-wave, SSEPs & BCR**

Intraoperative monitoring can help detect neurological abnormalities at an early stage, enabling rapid surgical intervention to prevent permanent neurological damage. Here we describe a summary of our sensory evoked potentials (SSEPs) and motor evoked potentials (MEPs) methodologies. The Cadwell Cascade IONM System is used for intraoperative stimulation and recordings.

**Motor Evoked potential**

Short trains of 5–9 square-wave stimuli of 0.5 ms duration and interstimulus interval (ISI) of 3 ms are delivered at a repetition rate of up to 2 Hz through screw electrodes placed at C1 and C2 scalp sites, according to the international 10-20 EEG system. The stimulation intensity ranges from 200 to 1000 V. MEPs are recorded via needle electrodes inserted into upper and lower extremity muscles bilaterally. For the cervical tumors, signals are usually recorded from the abductor digiti minimi for hands and tibialis anterior and the abductor hallucis for legs. For thoracic tumors, in addition to the above-mentioned muscles, we record from muscles rectus abdominis, iliopsoas, adductor magnus, vastus lateralis, gastrocnemius caput mediale and sphincter ani externus.

**D-wave**

When the spinal canal is open, the D-wave catheter is placed in the epi- or subdural space of the spinal cord distal (caudal) to the tumor. Whenever possible, we place an epidural electrode also proximal (rostral) to the tumor as a control recording. A single transcranial electrical stimulus is applied, using the same stimulation parameters as for MEPs. Baseline D-wave recordings are obtained before the opening of the dura mater. The important D-wave parameter is the amplitude, a decrease of more than 50% of the baseline value is considered to be associated with a long-term or permanent motor deficit. With the loss of muscle MEPs and preserved D-wave amplitude, a temporary motor deficit is expected to occur post-operatively.

**Somatosensory Evoked Potentials (SSEPs)**

For SSEP registration corkscrew electrodes are placed on the cortex with four localizations Fz', Cz', C3' and C4' according to the international 10-20 EEG system. Needle electrodes are placed over the plexus bilaterally. For electrical stimulation disposable electrodes or needle electrodes are placed on the median nerve and posterior tibial nerve bilaterally. The SSEP potential is defined based on the latency and duration in milliseconds (ms) and the amplitude in microvolts (μV). The electrical stimulation parameters vary around 10-30 mA.

The first response potential is registered over the brachial plexus and results in the response potential N9 which arises approximately 9 ms after the electrical stimulation. The second response comes from the somatosensory cortex contralaterally from the stimulation corresponding to the path of the nerve impulse to the cortex and is marked out as N20 and arises after about 20 ms.

**Bulbocavernosus reflex (BCR)**

Monitoring the bulbocavernosus reflex (BCR) is an intraoperative method to gain information about the sphincter function and the state of the sacral spinal cord segments (S2–S4) during spinal cord surgery. The dorsal nerves of the penis or clitoral are usually stimulated with bilateral electrical stimulation and recordings are obtained bilateral from the sphincter ani externus. In men disposable surface electrodes are used and active electrode is placed proximal and the reference on the distal penis. In women disposable electrodes or needle electrodes are used and the active electrode is placed in the clitoris and the reference is placed in labia majora. The recordings are made from the anal sphincter using needle electrodes. The stimulation settings were a single train of 5 stimulation pulses with duration of 500 μs, and the electrical stimulus intensity was between 20 mA to a maximum of 50 mA for generating a recordable BCR waveform.

We used the following alarm criteria in the analysis of the patients in the study.

* 50% decrease in SEP amplitude, 10% increase in latency,
* 80 % or more decrease or total loss of muscle MEP
* 50 % or more decrease in the D wave amplitude