Intraoperative neurophysiological monitoring for spinal tumor surgery: Workflow and set-up

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# Background

# Intraoperative neurophysiological monitoring

# Intramedullary spinal surgery

The aim of this retrospective study is to look at the possible correlation between intraoperative neurophysiological monitored parameters and postoperative outcome in a historical cohort of patient operated for intramedullary spine tumors at Karolinska from 2007-2021. This study will also be describing the workflow and logistics around the spinal procedures performed with neurophysiological monitoring at our department.

# Method

## Data Collection

All adult patients included in this study had undergone intramedullary spine surgery at Karolinska university hospital from 2007-2021.

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 was 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.

The following alarm criteria were used in the analysis of the patients in the study:

1. 50% decrease in SEP amplitude, 10% increase in latency
2. 80 % or more decrease or total loss of muscle MEP
3. 50 % or more decrease in the D wave amplitude

## Statistical Analysis

 Cox proportional hazard ratio regression models were used to assess the strength of associations between the endpoints and the explanatory variables.

# Ethical considerations

The study was approved by the national ethical authority: 2016/1708-31

Since this is a retrospective study, all data used in this study is already in the journal system of the hospital. No informed consent was needed when using this data retrospectively.

# Results

A total of 70 patients were included in the study, 27 female (38.6%) and 43 male (61.4%). The mean age of the patients was 43.4 (SD 15.5 years). The patients were monitored pre-surgery, during the surgery, and at follow-ups at 3 and long-term (6 months?).

There was a significant association between the intraoperative SEPs and the sensory function change at the follow-ups (Table 1 <combined SEP table!>). The odds of sensory function worsening at the 3-months follow-up compared to the pre-operative values were 25.19 times higher in patients had loss of intraoperative SEPs responses in their feet (right, left or both) compared to the patients whose intraoperative SEPs remained unchanged (OR 95% CI = 4.70 to 135.07, p-value < 0.001). The same odds ratio at the long-term follow-up was 11.00 (OR 95% CI = 2.76 to 43.80, p-value < 0.001).

# Discussion