HANDOUT

INTRAOPERATIVE NEUROMONITORING OF BRAINSTEM AND CRANIAL NERVES

Surgery related to lesions in the posterior fossa represents one of the most challenging procedures in neurosurgery and requires a detailed understanding of the microsurgical and functional anatomy. In the past, due to the high risk of severe postoperative neurological deficits, this surgery was restricted to biopsy procedures. The development of intraoperative neuromonitoring (IONM) over the last two decades, together with the emergence of more refined imaging techniques, better surgical instruments, and more effective neuroanesthesia and postoperative intensive care, have increased the feasibility and safety of brainstem surgery. Our review of IONM techniques for skull base surgery has revealed impressive developments during the last decade. Techniques to evaluate long pathways and motor cranial nerves during skull base surgery have been largely described. Nowadays, intraoperative neuromonitoring is mandatory during posterior fossa surgery since it has been proven that provides real time feedback on the functional integrity of the involved neural structures and allows the surgeon to modify the surgical strategy in order to avoid new deficits. The major advance in IONM for posterior fossa surgery is represented by the use of a multimodal methodology including a) Refined methods to evaluate cranial motor nerves eliciting corticobulbar motor evoked potentials; b) The implementation of intraoperative recording of brainstem reflexes (blink reflex, masseter reflex, laryngeal adductor reflex); c) Detailed study of free running EMG and d) continuous dynamic mapping of facial nerve, recently published. These techniques to assess the functional integrity of the different anatomical structures in or around the brainstem are complex and require skilled and knowledgeable team who ensure rapid and accurate acquisition and interpretation of electrophysiological data.

This presentation will put the focus on intraoperatively monitoring cranial nerves in the skull base surgeries. It has proven that reduces the risk of permanent postoperative deficits, aid in proper identification of specific neural structures and ensures that the therapeutic goal is achieved before the operation is ended. The first intraoperative neurophysiologic methodology for the study of cranial motor nerves (CMN) was the intraoperative identification of these nerves by electrical stimulation with handheld probe (MAPPING). This method was first applied for mapping the facial nerve because of the high incidence of loss of facial function in operations for acoustic neurinoma. The main limitation of this method is that does not provide continuous information on the functional integrity of CMN. For that reason, monitoring techniques have been developed.

The first one is the continuous monitoring of the EMG of cranial nerves supplying muscles in the absence of electrical stimulation. A wide variety of EMG patterns have been described. Romstöck et al. developed a classification system of EMG activity that was based on visual offline analysis of a multichannel, free-running EMG tracing with respect to waveform characteristics, frequencies, and amplitudes. One of these particular patterns, the 'A' train, described as a sinusoidal shape of high frequency and homogenous appearance with a long duration (around 10 seconds), was demonstrated to be the only pattern that clearly indicated post-operative paresis with high sensitivity and specificity. However, a considerable number of false positive and false negative results were observed. False negative results might be explained by the fact that not all muscles innervated by the studied nerve are monitored, and consequently some information is missed. In 2005, Ashram et al. demonstrated that the intermedius nerve carries motor fibers, which target the perioral facial muscles, in contrast with established belief. Ten years later Prell et al. found an explanation for the false positive results while monitoring A-trains on the bases of Ashram's publication. They observed that the manipulation of the intermedius nerve which runs a course that is at least partly separated from the main trunk of facial nerve leads to A-train activity without any clinical correlation, therefore causing false positive results. Nevertheless, the neurotonic discharges observed during skull base surgery offer a valuable information concerning the proximity or risky manipulation of the nerve.

The second method to continuously evaluate the functional integrity of CMN consists in eliciting corticobulbar motor-evoked potentials in the innervated muscles. This method is complex and full of technical features that are important in order to provide more reliable information. Thus, the correct interpretation of CoMEPs changes during surgery allows taking intraoperative measures in time, in order to avoid permanent neurological deficits. Dong et al. were the first to describe a methodology for continuously monitor the corticobulbar tract (CBT) for the facial nerve by eliciting facial motor evoked potentials with transcranial stimulation during skull base surgery (Dong et al., 2005). Deletis et al., 2009 described methodology for continuous monitoring of CBT for vagal nerves. The method for intraoperative monitoring CBT for other CMN has not been yet described.

In its anatomical definition, the CBT is formed by axons that are homologous to corticospinal fibers but terminate in the motor nuclei of the cranial nerves in the brain stem (e.g., nuclei V, VII, IX, X, XI and XII. Thus, they are the axons of the upper motor neurons that synapse on the lower motor neurons of the cranial nerves. The corticobulbar fibers accompany the corticospinal axons through the internal capsule and cerebral peduncle and then gradually leave the corticospinal tract to enter the tegmentum of the pons and medulla to terminate in the different CMN nuclei.

METHODOLOGY

Previous experience with transcranial electrical stimulation (TES) in anesthetized patients has shown that temporal summation of multiple descending volleys is necessary to activate lower motor neurons (Taniguchi et al. 1993). Therefore, it is necessary to use a short train of electrical stimuli to activate CBT and to record CoMEPs from the innervated muscles by each CMN.

STIMULATION PARAMETERS

It was used transcranial electrical stimulation consisting of a short train consisting of 3 to 5 stimuli with 0.5 ms duration each. These stimuli are separated by 2 ms interstimulus interval, with a train repetition rate of 2 Hz and an intensity of up to 120 mA. The montage is C3 (+) vs. Cz (-) for left hemispheric stimulation and C4 (+) vs. Cz (-) for right hemispheric stimulation. Ninety milliseconds after the train we delivered a single stimulus over the same stimulating montage. The rational for this kind of stimulation is the fact that in most patients under general anesthesia only a short train of stimuli can elicit “central” responses generated by the motor cortex or subcortical part of CBT. If a single stimulus elicits a response, this should be considered a “peripheral” response which activates the CN directly (Dong et al., 2005; Ulkatan et al., 2007).

Electrical stimuli are delivered through subcutaneously placed corkscrew electrodes over the scalp (CS electrode, Viasys Healthcare WI, MA, USA). The intensity of TES is determined when CoMEPs that appear in the muscles are equal to or 10 to 20 mA higher than the set threshold for eliciting MEPs in the contralateral abductor pollicis brevis muscle.

RECORDING PARAMETERS

To record CoMEPs from the different muscles we use two hook wire electrodes, and each consisted of a teflon coated wire 76 μm in diameter passing through 27-gauge needles (hook wire electrode, specially modified, Viasys Healthcare WI, MA). The recording wires have stripped 2 mm from Teflon isolation at the tip and are curved to form the hook to anchor them in the muscle after the needle is withdrawn. The impedance of electrodes was below 20 Kohl. When the patient is intubated, two electrodes are inserted in each muscle. After inserting the wire electrodes in the muscles, wires are twisted, and needles are withdrawn and covered in order to protect the patient from a possible accidental injury. The intensity of TES was adjusted at the level of maximal amplitude of CoMEPs (suprathreshold intensity). Depend on specific surgeries, recordings are performed from the following muscles:

- V CN (Trigeminal): Masseter muscle.
- VII CN (Facial) : Frontalis, Orbicularis Oculi, Nasalis, Orbicularis Oris, Mentalis muscles.
- IX CN (Glossopharyngeal): Posterior wall of oropharynx.
- X CN (Vagal): Vocal cord or cricothyroid muscle.
- XI CN (Accesori spinal): Trapezius muscle.
- XII CN (Hypoglossal): Lateral side of the tongue.

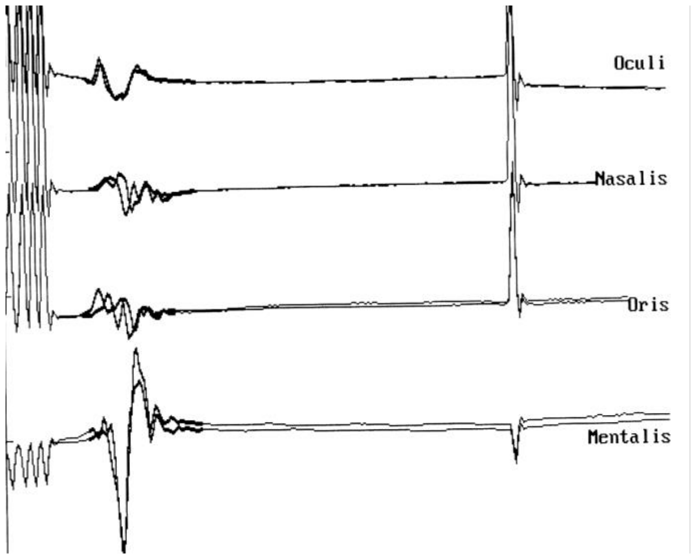

Figure 1. *Example of normal parameters of the CoMEPs for the facial nerve. The responses were obtained after the train of stimuli but not after single stimuli from each muscle innervated by different brunches of the facial nerve.*

IMPLEMENTATION OF BLINK REFLEX RECORDINGS DURING BRAINSTEM AND POSTERIOR FOSSA SURGERY:

The blink reflex is elicitable under general anesthesia after delivering a short train of stimuli over the supraorbital nerve in most of the patients. Therefore, BR opens a new door for intraoperative neuromonitoring. The evaluation of the blink reflex during surgery offers the opportunity to assess continuously and in real-time the functional integrity of all anatomical structures involved in the reflex arc since it does not produce any movement of the patient and the surgical field is not disturbed.

As it has been demonstrated the importance of using a multimodal protocol during surgical procedures, it is remarkable the observed correlation between the behavior of blink reflex and the trigeminal and facial corticobulbar motor evoked potentials during surgery. They complement each other and may help to understand if injury to the structures involved occurs and, therefore, to change the surgeon strategy in order to avoid a permanent new neurological deficit.

To conclude, the methodology to elicit the first component of blink reflex is feasible and reliable and it might be considered to be implemented it in the routine of intraoperative neuromonitoring protocols.

RECOMMENDED LITERATURE:

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