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Short-Communication

Intraoperative Neurophysiological Monitoring during the Clipping of Unruptured Intracranial Aneurysm: A Short Communication on its Optimal Protocol and Application in the Real Field

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BACKGROUND

Intraoperative Neurophysiological Monitoring (IONM) has been applied to surgeries related to the nervous system, such as cerebrovascular surgeries, spinal surgeries, and peripheral nerve surgeries [1-3]. Modalities applied to IONM detect changes in a neural-functional state. Through this, their role is recognized not only in correcting adverse events during surgery but also in predicting the patient's recovery after surgery [4].

Among the various modalities applied to IONM, Evoked Potentials (EP) are key methods to confirm the neurophysiological integrity of the central nervous system [5]. Especially during Unruptured Intracranial Aneurysm (UIA) clipping surgery, Motor Evoked Potential (MEP) and Somatosensory Evoked Potential (SSEP) are mainly interpreted. MEP reflects the motor pathway originating from the primary motor cortex and is more sensitive to subcortical ischemia [6]. On the other hand, SSEP reflects the sensory pathway leading from the peripheral nerve to the primary sensory cortex and generally reflects the cortical ischemia and the overall cerebral perfusion state [7]. In previous studies, the response of MEP was known to be faster and more sensitive than that of SSEP [6-8].

Previous studies related to UIA clipping with IONM consistently reported that the rate of Postoperative Neurologic Deficit (PND) was much lower when IONM was applied [9]. However, a closer look at these studies revealed that they had different criteria for evaluating PND. The definitions of persistent or transient PND were also diverse. Moreover, since the IONM protocol used differed slightly between the studies, such differences might lead to differences in the responses to the intraoperative events and overall outcomes. Therefore, the authors consider that standardization of the IONM protocol is necessary. Also, active discussions among experts using IONM are needed for establishing a practically applicable protocol. These discussions can provide accurate information to those who use the IONM. Furthermore, such discussions can also demonstrate standardized postoperative outcomes in UIA clipping in the future.

NOTEWORTHY POINTS WHEN ESTABLISHING THE IONM PROTOCOL

We have introduced a detailed, and practically applicable IONM protocol of UIA clipping in our single-center, retrospective study [10]. In this section, we aimed to discuss the several important points from our IONM protocol.

The first point to be discussed is the timing of acquiring the baseline EP.

In the majority of studies performed on UIA clipping with IONM, EP obtained just before dura opening was used as baseline data [11,12]. This is to exclude the effect of a single bolus of Neuromuscular Blocking (NMB) agent on MEP used before intubation. In our institution, 0.4–0.5 mg/kg of rocuronium bromide was administered before intubation. From our cohort dataset, we found that the median value of time from the NMB administration to the dura opening was 57 minutes. This value indicates that we were able to sufficiently exclude the effect of a single bolus of NMB on the baseline MEP [13]. Obtaining baseline EP after opening the dura may not be optimal due to the following two reasons. First, underestimation of EP may occur due to cerebrospinal fluid drainage or brain shrinkage, which may cause a false-negative result. Second, retractor-induced parenchymal compressive injury may occur after dura opening which can affect the EP findings. Therefore, in agreement with the majority of previous studies, we concluded that the most optimal time to acquire baseline EP is just before dura opening. For the interpretation of baseline EP, a preoperative EP study is required [14]. When there is a problem with the baseline EP in the operating room, this can help discriminate whether it is due to mechano-environmental causes or the patient's baseline neurologic deficit. Therefore, we recommend perform a preoperative EP study to be performed

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within 48 hours before surgery for patients scheduled to undergo UIA clipping with IONM.

Second, after clipping, continuous monitoring is recommended until dura closure.

Surgical procedure is not affected by the stimulation and recording of SSEP. On the other hand, surgical procedure should momentarily be stopped when MEP is stimulated. Therefore, frequent MEP stimulation can considerably annoy the surgeon. To prevent such inconvenience, during the non-critical portion of the surgery, our IONM protocol calls for MEP to be evaluated at set times while SSEP is regularly evaluated. However, after temporary clip (TC) or permanent clip (PC) application, our protocol recommends for a regular check-up of both MEP and SEP until dura closure. In our study, the median values of the reaction times of MEP and SEP were 8 minutes and 12 minutes, respectively, indicating that the EP responses were not immediate. In particular, the EP response for PC may be much slower than that of TC because complete parent artery closure does not occur [8, 11]. Vasospasm of proximal or distal artery that occurs after PC may also be detected after a certain period of time [15]. Therefore, after applying the clip, we recommend maintaining continuous monitoring of MEP as well as SSEP until dura is closed.

Third, any changes in EP–whether MEP or/and SSEP–should be sensitively interpreted, and corresponding rescue interventions should be applied.

The deterioration of EP that occurs during UIA clipping surgery may be a change in MEP or SSEP alone, or both EP changes may appear. Some studies have shown that the results of IONM with MEP or SSEP alone were also reliable [16-18]. Nevertheless, our results showed the best diagnostic efficacy when predicting PND based on changes in any EP modality. This showed not only much higher sensitivity than the case of predicting PND with MEP or SSEP alone but the negative predictive value (NPV) was higher. These results support the findings of previous studies that the better postoperative outcome could be achieved when the IONM was performed with multimodal EP monitoring [12,19, 20]. When considering changes in all EP–both MEP and SSEP–for PND prediction, the specificity was high. Still, the sensitivity was very low, and the NPV was also inferior to the single EP.

CONCLUSIONS AND FUTURE DIRECTION

The IONM protocol during UIA clipping should guarantee maximal patient safety, be tailored, and be applicable for the multi-disciplinary team. A further study needs to be performed on a large-scale with multi-centers that share the same IONM protocol and surgical methods. We expect such a collaborative effort to present standardized results. For this reason, the authors consider it is important to establish and share the detailed IONM protocol that is readily applicable in the real field.

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