Case Series: Advantages and pitfalls of Neruophysiologic intraoperative monitoring (NIOM)

주병억, 서대원

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New data and information in the field of stroke have been reported last year. Immediate and acute blood pressure lowering was attempted for acute management of ischemic and hemorrhagic stroke. In terms of the medications, new oral anticoagulant, edoxaban, for the primary and secondary prevention in non-valvular atrial fibrillation was reported and dual antiplatelet therapy in acute stage of ischemic stroke has accumulated the evidence for clinical use. In this review, all the results and information about primary prevention, acute management and secondary management will be discussed in the order named.

Key Words: Stroke, Prevention, Acute management

Introduction

Neurophysiologic intraoperative monitoring (NIOM) has grown over three decades into a method widely used to prevent neurologic injury during surgery. Common NIOM techniques include electroencephalography (EEG), electromyography (EMG), evoked potentials (EPs), and nerve conduction velocity (NCV). NIOM can warn the surgeon of changes in time to correct problems and prevent postoperative neurologic deficits. By using NIOM to assess a patient's neurologic safety, a surgeon may provide a more thorough procedure or operate on a high-risk patients who might otherwise be turned away. Finally, patients and families can take comfort that neurologic risks are being evaluated during surgery. Though the technology of the NIOM has been developed and NIOM has significantly reduced the risk of nerve damage during surgery, there are still some limitations for NIOM to prevent nerve damage during surgery. False alarms do occur sometimes, those are cases when the NIOM warns of changes, but the patient awakens from surgery without a new deficit. False negative cases are those in which a patient suffers a postoperative neurologic injury that was not predicted by NIOM. Some injuries are in pathways that were not monitored. We will here present several cases that showed some limitations of the current NIOM.

Case reports

1. Monitoring using Direct cortical stimulation and transcranial electrical stimulation motor evoke potentials during supratentorial cortical tumor resection

Surgery for tumors near the sensorimotor cortex poses risks to sensory and motor pathways. Sensory pathways are monitored successfully with somatosensory-evoked potentials (SEP), but motor pathways pose different challenges. Historically, electrical stimulation with prolonged 60 Hz trains was used to map the motor cortex, but this method has a high incidence of induced seizures. Transcranial motor-evoked potentials (tcMEP) can monitor spinal motor pathways. However, transcranial stimulation is inappropriate for intracranial tumors, since the current

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may activate deep corticospinal fibers, bypassing a superficial injury. In contrast, brief high-frequency trains as used for tcMEP, applied directly to the cortical surface at lower intensity, avoid this problem and do not appear to induce seizures. Once the motor cortex has been mapped, an electrode can be left in place and used for continuous monitoring of corticospinal tract function during tumor resection.

2. Monitoring of flashed visual evoked potentials in transsphenoidal surgery.

Postoperative visual outcome is a major concern when performing surgery for timorous condtions around the visual pathway. Several researches have demonstrated the importance of intraoperative visual evoked potential (VEP) monitoring during pituitary surgeries since the first report of VEP monitoring during orbital tumor surgery. However, difficulties encountered in delivering stable visual stimuli and obtaining reproducible VEP recordings renders the clinical usefulness of these recordings unclear. Although new light-stimulation devices and intravenous anesthesia have overcome these technical difficulties and enhanced the feasibility of intraoperative VEP monitoring. A consensus has yet to be reached about whether using VEP as a monitoring tool provided results that are clinically meaningful. But, intraoperative VEP with scalp electrodes under total venous anesthesia had the reproducibility of the high rate during transsphenoidal surgery for sellar or perisellar lesons. However, the intraoperative VEP waveforms showed no association with postoperative visual outcomes.

3. Monitoring of BAEP in Microvascular Decompression Surgery for Patients with Hemifacial Spasm.

Hemifacial spasm (HFS) is defined as the unintended twitching of one side of the face. It typically begins in the upper face or lower eyelid and spreads over years to involve other areas of the face. It is usually caused by pulsatile vascular compression on the root exit zone (REZ) of the facial nerve. Microvascular decompression (MVD) surgery was known as the most effective treatment among those options, showing a high success rate ranging from 83 to 97%.However, as MVD surgery involves relieving the neurovascular conflict physically, MVD surgery for HFS may cause ipsilateral hearing impairment from injury to cranial nerve VIII (CN VIII). The use of NIOM of brainstem auditory evoked potentials (BAEP) has been shown to decrease the risk of hearing impairment with MVD. Though many studies have suggested that N IOM of BAEP is useful for reducing the risk of hearing impairment, no universally accepted criteria are available to determine when an obtained BAEP change is significant and warrants alerting the surgeon. When we performed NIOM of BAEP using the protocol that it took more than 10 seconds, some patients sometimes initially showed a slight change in the amplitude and latency of the V wave, and then presented severe waveform change such as complete loss of wave V in BAEP obtained after a second averaging.

4. Monitoring of oculomotor function

The extraocular muscles controlling eye movement are innervated by the oculomotor (CN III), trochlear (CN IV), and abducens (CN VI). In certain skull-based, brainstem, anterior fossa, cavernous sinus, and orbital surgical procedure, oculomotor function may be at risk and, therefore, NIOM of the oculomotor system is vital to preserve neural function. Oculomotor, trochlear, and abducens CN activity can be effectively monitored using EMG because their functions are almost exclusively motor. Although there are many practitioners familiar with EMG, its application in the operating room differs from that practiced in the neurodiagnostic laboratory. Patients in the operating room are under anesthesia, and muscle activity cannot be assessed under volitional effort. The premise for using EMG as a monitoring technique is based on the principle of recording muscle fiber-generated electrical potentials and can be performed using surface, subcutaneous, or intramuscular electrodes. In general, surface and subcutaneous electrodes are considerable less desirable because these electrodes are not placed in the muscle and distant motor unit potentials (MUPs) can be missed. It may also prove difficult to identify the specific muscle generating the EMG activity. Using intramuscular electrodes improves the signal-to-noise ratio and allows for 'near-field' recordings because the recording electrode is in the muscle, close to the neural generator. Conventional subdermal EEG needle and wire electrodes are the two main types of intramuscular electrodes currently used for EMG. The specific type and length of the needle electrodes used depend on the location and depth of the target muscle.

5. Monitoring for microsurgical removal of conus medullaris tumor

Neruological intervention for conus medullaris tumor is to remove the tumor and untether the nerve roots, in order to improve neurological deficits and prevent further progression of the pathology. Because the tumor usually adheres strongly to the spinal cord and the exiting nerve roots and the tumor tissue invades into the dura, it was known that an surgical morbidity was relatively high. Various neurophysiologic examination techniques are used to reduce the risk of iatrogenic neurologic deficits in spinal cord surgery. These technique serve to detect nerve tissue in the operating site and to monitor its function until the end of the operation. Motor evoked potentials (MEP) have been used to monitor descending pathways. After transcranial electric or magnetic stimulation, muscle response potentials can be recorded electromyographically from defined muscles of the extremities. Somatosensory evoked potentials (SEPs) are suitable for monitoring ascending pathways. Free-running and triggered electromyography (EMG) are two methods for directly testing nerve fibers in the operation site. The continuous monitoring of the free-running EMG will show any mechanical manipulations of the nerve roots (e.g. during tumor removal). The direct electrical stimulation of triggered EMG can be used to test the transmission capacity of nerve roots. So far there are no evidence-based recommendations on the choice of the best and most reliable monitoring procedure or combination of procedures.

Discussion

The usefulness of NIOM in surgery has been reported in many studies over the years. However, most of the protocol and warning criteria in NIOM were determined on the basis of experience, and there was no gold standard in particular about the warning criteria in NIOM. Also there are a limit when performing NIOM using the current method in specific disease. Ongoing research about the protocol and warning criteria of NIOM to detect and prevent nerve injury more appropriately during surgery will be required.

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