Is intraoperative neuromonitoring a good idea in my practice?

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Summary

Intraoperative neuromonitoring (IONM) is a growing field within neurology. IONM uses a variety of neurophysiologic modalities to detect signs of potential injury to neural structures while a patient is undergoing surgery. An early warning to the surgeon about signal changes may prevent permanent neurologic disability. Since all monitoring is done in real time, the work pace is fast. The operating room environment poses additional challenges for signal acquisition and interpretation. Specific training in the field is becoming increasingly available. Several practice models exist and IONM can be performed in an academic or a private practice setting. A career in intraoperative neuromonitoring can offer lots of opportunities, a high degree of job satisfaction, and flexibility to those choosing to enter the field.

Over the past decade, intraoperative neuromonitoring (IONM) has emerged from being a small new field with a handful of dedicated practitioners to become a bona fide subspecialty of neurology, or more specifically of neurophysiology. The possibility of gathering functional information about a patient's nervous system while he or she is undergoing surgery is exciting. From its early beginnings in the 1930s to its current use, IONM has seen tremendous growth: indications today are not only limited to neurosurgical cases but include also orthopedic, vascular, cardiothoracic, as well as ENT surgeries. The evidence for the success of the technique is compelling in that IONM has been shown to reduce the morbidity of many procedures with the potential to negatively impact neural structures.¹⁻³ Furthermore, considering the high costs of health care related to spinal cord injury, it is important to note that IONM during spine surgeries is demonstrably cost effective.⁴ Intraoperative neuromonitoring did not develop according to a curriculum; it developed out of the need to make surgeries safer. As a result several practice models have evolved and IONM is now being performed in a variety of settings: academic institutions may have dedicated IONM teams, private practitioners may work together with local hospitals to provide the service, and small as well as large companies dedicated to IONM have been

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established. Advances in telecommunication and the Internet have enabled remote monitoring of several cases simultaneously in real time. The growth in this field still offers lots of opportunities; in fact there is a critical need for more, well-trained neurologists with expertise in IONM. So what are the unique aspects and challenges of intraoperative neuromonitoring? What kind of training is available? What are the logistics of incorporating IONM into a neurology practice? What are the rewards?

IONM: Clinical considerations

Surgeries on or in proximity to nervous tissues involve the risk of neural injury. With the help of IONM, injuries in the surgical field can be detected before they lead to permanent deficits. In order to achieve this, evoked potentials (EPs), EEG, and EMG are performed and interpreted “live” and continuously so that the surgeons can be warned immediately if neurophysiologic evidence of a potential injury is seen. While somatosensory evoked potentials were the mainstay of IONM in the 1990s,¹ over the last decade motor evoked potentials have made a clear impact on the field. The safety of electrical current delivery to motor cortex has been established.⁵ Just this year, the American Academy of Neurology published the updated evidence-based guideline on intraoperative spinal monitoring with somatosensory and transcranial electrical motor evoked potentials (TcMEPs).⁶ Thus real-time monitoring with motor evoked potentials is a proven method for the intraoperative assessment of the cortical-spinal tracts. However, the now frequent use of TcMEPs is not the only factor that sets IONM apart. The interpretation of neurophysiologic data traditionally happens “off-line” and for the purpose of the diagnosis of neurologic disease. In contrast, IONM happens “on-line,” in real time, and for the purpose of maintaining the status quo, or in other words to prevent (further) neurologic injury. Therefore, performing and interpreting intraoperative neuromonitoring is considerably different from obtaining diagnostic EPs, EEGs, or EMGs in the laboratories: surgeries are fast paced. Signal optimization can be difficult in an operating room with many sources of electrical noise. The goal of signal acquisition in the operating room is not to invest time into getting the most beautiful waveforms but rather to get a useful baseline that can be followed throughout the case. The patient serves as his or her own control. Previously diagnosed or undiagnosed neurologic conditions may adversely affect signal quality and other signal characteristics. Yet, the data gathered are not typically used for diagnostic purposes: rather, one aims to work around poor signals, using tricks and techniques geared to optimize the responses so that pertinent information may still be extracted and monitoring can proceed. Other systemic factors including the patient’s temperature and blood pressure variations may also impact IONM signals and need to be followed. Importantly, anesthetic agents affect each

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signal modality in a different way and need to be considered as part of the signal interpretation. A good working relationship with the anesthesiologist is of paramount importance and goes both ways: the IONM personnel need the help of the anesthesia team to ensure the best possible anesthetic environment for each individual patient. The anesthesia team may benefit from getting information about the depth of anesthesia or about the level of neuromuscular blockade. Finally, while everything already moves fast, emotions can run high when there is a sudden signal loss: troubleshooting needs to be completed quickly, the surgeon needs to be informed immediately, and the significance of the findings needs to be explained clearly and unequivocally if neurologic injury is to be successfully avoided.

Training issues in IONM

Dedicated training is necessary to ensure that the supervising neurologist can meet all the challenges IONM poses. At present, neurophysiology fellowships typically include an IONM rotation for interested trainees, but IONM is often not the main focus of the training. This is unfortunate, since there is no substitute for experience in the field: signals are easy to interpret and follow when they are well formed and stable, which is often but certainly not always the case. When signals are poorly formed, interpretation becomes much more difficult and extensive troubleshooting may be necessary to identify and eliminate factors that negatively impact signal quality. Most importantly, every trainee should participate in several cases where signals are lost. Decisions need to be made quickly and this is not the time for a “second opinion” from a more experienced colleague. Surgical complications are uncommon in experienced hands, so it may take a trainee a while to see a case with signal changes. After completion of all relevant training, certification for physicians is available from the American Board of Clinical Neurophysiology (ABCN), which offers a dedicated IONM examination. The Clinical Neurophysiology subspecialty examination of the American Board of Psychiatry and Neurology (ABPN) also includes some questions on IONM although a passing grade in the examination does not establish expertise in the field since the examination’s focus is on EEG and EMG. While there is no real substitute for gaining experience through hands-on training, the need for better IONM training has been recognized: Several professional societies, including the American Clinical Neurophysiology Society (ACNS), the American Society of Neurophysiological Monitoring (ASNEM), the American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM), and the American Academy of Neurology (AAN) now offer 1- or 2-day courses in IONM. As IONM gains momentum, a number of excellent textbooks on the subject have become available. These address issues of signal interpretation as well as the all-important issues of troubleshooting the signals quickly and efficiently.^{7–9} The number of scientific publications in the field is also increasing with neurophysiology journals in particular publishing state-of-the-art original research as well as comprehensive review articles. Ultimately though, even with the best training possible, the importance of working with skilled, expert technologists cannot be overemphasized.

IONM practice models

In practice, IONM requires a team approach. The setup for monitoring as well as the signal acquisition is typically performed by a trained technologist ideally holding a certification in neurophysiologic intraoperative monitoring (CNIM, www.abret.org). The technologist has to be physically present in the operating room for the entire duration of the surgery while remaining under the constant supervision of an IONM-trained physician solely dedicated to

monitoring. The physician, usually a neurologist, may be on-site or off-site but should provide continuous real-time monitoring (online or in person) and have the ability to communicate with the technologist promptly (AAN Model Medical Policy: AAN Principles of Coding for Intraoperative Neurophysiological Monitoring and Testing [IOM], updated February 2012; <http://www.aan.com/globals/axon/assets/9339.pdf>). Academic centers often have a dedicated IONM team consisting of several technologists as well as IONM physicians and perhaps additional midlevel providers and fellows. The advantages of the in-house setup are obvious: the IONM physicians know their technologists well and also have a close working relationship with the surgeons and anesthesiologists. The academic practice model has evolved out of the need for the supervising physician to be physically present in the operating room suite, walking from operating room to operating room while several cases are monitored. Today, the use of the Internet generally permits real-time monitoring from the physician's on-site office. However, the fact that the neurologist is on the premises allows for personal consultation in the operating room if necessary or desired. Smaller community hospitals often do not have the case volume to warrant an on-site IONM team. They may bring in technologists through an agency or may employ their own while contracting with neurologists in private practice to supervise them. Since one neurologist may supervise several cases simultaneously, he or she can provide IONM at several hospitals at the same time. A state license and clinical privileges at each hospital are typically required. The logistics for this kind of setup can be very straightforward: a neurologist in private practice or a small academic setting may contract with a company that provides the technologists and equipment or even with a freelancing technologist who owns his or her machine on one hand and with a hospital or hospitals desiring the service on the other. In this scenario the hospitals absorb cost for the technical personnel and the equipment while the physician may bill the patient's insurance directly for the professional fees. The monitoring neurologist bills separately for the interpretation of each modality as baseline testing and after that bills a separate code for each hour monitored per case. Reimbursement is tied to how many cases are monitored simultaneously, with some carriers limiting the number to 1 or 3. The private practice setup does not allow for on-site monitoring on part of the physicians but since the scope of the practice remains limited, trusting relationships between the monitoring neurologist and the technologists as well as the surgeons can develop. A third practice model involves private companies that provide all equipment and personnel involved in monitoring. Trained technicians often travel significant distances to provide the service wherever there is a need while being supervised by a centrally located IONM physician also employed by the company. Again, local licensing and credentialing are typically required. While the professional working relationships between monitoring physician, technologist, and surgeons may not be as strong in this type of setup, it allows for bringing IONM to small hospitals and remote areas around the country. In these cases, the IONM company handles the financial aspects of the transaction while the neurologists are typically salaried employees.

IONM: For the benefit of the patient

However performed, if a skilled monitoring team works closely with the surgical team, IONM is comprehensive patient care at its best. At our institution, we monitored somatosensory evoked potentials (SEPs) and EEG in a patient undergoing the elective clipping of a right ophthalmic artery aneurysm last September. All signals remained stable throughout the clipping procedure. However, shortly after clipping, there was a sudden loss of the right median and right posterior tibial cortical SEPs. This finding was unexpected since it indicated a compromise of left hemispheric structures—contralateral to the side of the surgery. The angiography team quickly injected dye into the left common carotid artery and found it to be completely occluded. The patient underwent emergent mechanical thrombectomy and chemical thrombolysis of the left common carotid and antegrade blood flow was re-established. The patient had a protracted hospital course followed by neurorehabilitation. Today I learned that at follow-up she had fluent speech, only mild weakness of her right hand, and a normal gait. Today was a good day.

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