Intraoperative Neurophysiologic Monitoring (Sensory-Evoked Potentials, Motor-Evoked Potentials, EEG Monitoring)

Description

Intraoperative neurophysiologic monitoring (IONM) describes a variety of procedures that have been used to monitor the integrity of neural pathways during high-risk neurosurgical, orthopedic, and vascular surgeries. It involves the detection of electrical signals produced by the nervous system in response to sensory or electrical stimuli to provide information about the functional integrity of neuronal structures.

Background

The principal goal of intraoperative monitoring is the identification of nervous system impairment in the hope that prompt intervention will prevent permanent deficits. Correctable factors at surgery include circulatory disturbance, excess compression from retraction, bony structures, or hematomas, or mechanical stretching. The technology is continuously evolving with refinements in equipment and analytic techniques including recording, with several patients monitored under the supervision of a physician who is outside the operating room.

The different methodologies of monitoring are described next:

Sensory-evoked Potentials

Sensory-evoked potential (SEP) describes the responses of the sensory pathways to sensory or electrical stimuli. Intraoperative monitoring of SEPs is used to assess the functional integrity of central nervous system (CNS) pathways during operations that put the spinal cord or brain at risk for significant ischemia or traumatic injury. The basic principles of SEP monitoring involve identification of a neurological region at risk, selection and stimulation of a nerve that carries a signal through the at-risk region, and recording and interpretation of the signal at certain standardized points along the pathway. Monitoring of SEPs is commonly used during the following procedures: carotid endarterectomy, brain surgery involving vasculature, surgery with distraction compression or ischemia of the spinal cord and brainstem, and acoustic neuroma surgery. Sensory-evoked potentials can be further broken down into the following categories according to the type of simulation used:
Somatosensory-evoked potentials (SSEPs) are cortical responses elicited by peripheral nerve stimulations. Peripheral nerves, such as the median, ulnar, or tibial nerves are typically stimulated, but in some situations the spinal cord may be stimulated directly. Recording is done either cortically or at the level of the spinal cord above the surgical procedure. Intraoperative monitoring of SSEPs is most commonly used during orthopedic or neurologic surgery to prompt intervention to reduce surgically induced morbidity and/or to monitor the level of anesthesia. One of the most common indications for SSEP monitoring is in patients undergoing corrective surgery for scoliosis. In this setting, SSEP monitors the status of the posterior column pathways and thus does not reflect ischemia in the anterior (motor) pathways. Several different techniques are commonly used, including stimulation of a relevant peripheral nerve with monitoring from the scalp, from interspinous ligament needle electrodes, or from catheter electrodes in the epidural space.

Brainstem auditory-evoked potentials (BAEPs) are generated in response to auditory clicks and can define the functional status of the auditory nerve. Surgical resection of a cerebellopontine angle tumor, such as an acoustic neuroma, places the auditory nerves at risk, and BAEPs have been extensively used to monitor auditory function during these procedures. Visual-evoked potentials (VEPs) with light flashes are used to track visual signals from the retina to the occipital cortex. VEP monitoring has been used for surgery on lesions near the optic chiasm. However, VEPs are very difficult to interpret due to their sensitivity to anesthesia, temperature, and blood pressure.

Motor-evoked Potentials

Motor-evoked potentials (MEPs) are recorded from muscles following direct or transcranial electrical stimulation of motor cortex or by pulsed magnetic stimulation provided by a coil placed over the head. Peripheral motor responses (muscle activity) are recorded by electrodes placed on the skin at prescribed points along the motor pathways. MEPs, especially when induced by magnetic stimulation, can be affected by anesthesia. The Digitimer electrical cortical stimulator received U.S. Food and Drug Administration (FDA) premarket approval in 2002. Devices for transcranial magnetic stimulation have not yet received approval from the FDA for this use.

EMG (Electromyogram) Monitoring and Nerve Conduction Velocity Measurements

Electromyogram (EMG) monitoring and nerve conduction velocity measurements can be performed in the operating room and may be used to assess the status of the peripheral nerves, e.g., to identify the extent of nerve damage prior to nerve grafting or during resection of tumors. In addition, these techniques may be used during procedures around the nerve roots and around peripheral nerves to assess the presence of excessive traction or other impairment. Surgery in the region of cranial nerves can be monitored by electrically stimulating the proximal (brain) end of the nerve and recording via
EMG in the facial or neck muscles. Thus monitoring is done in the direction opposite that of SEPs, but the purpose is similar—to verify that the neural pathway is intact.

**EEG (Electroencephalogram) Monitoring**

Spontaneous EEG monitoring can also be recorded during surgery and can be subdivided as follows:

- EEG monitoring has been widely used to monitor cerebral ischemia secondary to carotid cross clamping during a carotid endarterectomy. EEG monitoring may identify those patients who would benefit from the use of a vascular shunt during the procedure to restore adequate cerebral perfusion. Conversely, shunts, which have an associated risk of iatrogenic complications, may be avoided in those patients in whom the EEG is normal. Carotid endarterectomy may be done with the patient under local anesthesia so that monitoring of cortical function can be directly assessed.

- Electrocorticography (ECoG) is the recording of the EEG directly from a surgically exposed cerebral cortex. CoG is typically used to define the sensory cortex and to map the critical limits of a surgical resection. ECoG recordings have been most frequently used to identify epileptogenic regions for resection. In these applications, ECoG does not constitute monitoring, per se.

**Related Policies**

2.01.90 Navigated Transcranial Magnetic Stimulation

**Policy**

*This policy statement applies to clinical review performed for pre-service (Prior Approval, Precertification, Advanced Benefit Determination, etc.) and/or post-service claims.*

Intraoperative monitoring, which includes somatosensory-evoked potentials, motor-evoked potentials using transcranial electrical stimulation, brainstem auditory-evoked potentials, EMG of cranial nerves, EEG, and electrocorticography (ECoG), may be considered **medically necessary** during spinal, intracranial, or vascular procedures.

Intraoperative monitoring of visual-evoked potentials is considered **investigational**.

Due to the lack of FDA approval, intraoperative monitoring of motor-evoked potentials using transcranial magnetic stimulation is considered **investigational**.

Intraoperative EMG and nerve conduction velocity monitoring during surgery on the peripheral nerves is considered **not medically necessary**.

Note: These policy statements refer only to use of these techniques as part of intraoperative monitoring. Other clinical applications of these techniques, such as visual-evoked potentials and EMG, are not considered in this policy.
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Subsection: Surgery
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Subject: Intraoperative Neurophysiologic Monitoring (Sensory-Evoked Potentials, Motor-Evoked Potentials, EEG Monitoring)

Policy Guidelines

Constant communication between surgeon, neurophysiologist, and anesthetist are required for safe and effective intraoperative neurophysiologic monitoring.

Rationale

Intraoperative monitoring of neurologic function is a widely diffused practice, particularly during cervical and thoracic spinal surgery and without a strong evidence-based support through controlled trials. There have been several references that have looked at the efficacy of this technology and the controversies surrounding its use. (1-4) Intraoperative monitoring has been used particularly during cervical and thoracic spinal surgery. A review of the literature through a search of MEDLINE database, focused on intraoperative-evoked potentials. It appears that monitoring of motor-evoked potentials (MEPs), particularly for spine surgery and open abdominal aorta aneurysm repairs, has broad acceptance though the evidence base consists mainly of observational studies.

In 2010, Fehlings et al published a systematic review of the evidence for improved outcomes from IONM for patients undergoing instrumented spine surgery. (5) The authors identified 32 articles that met their inclusion criteria. The overall strength of the evidence for unimodal somatosensory-evoked potentials (SSEPs) and motor-evoked potentials (MEPs) studies was very low. The review found a high level of evidence that multimodal IONM is sensitive and specific for detecting neurologic injury during spine surgery, with most studies reporting sensitivity and specificity above 90%. There was a low level of evidence that IONM reduces the rate of new or worsened perioperative neurologic deficits, based on 4 observational studies that compared patients with and without neuromonitoring. There was very low evidence that an intraoperative response to a neuromonitoring alert reduces the rate of perioperative neurologic deterioration, with only 1 comparative study identified.

In 2012, the American Academy of Neurology (AAN) and the American Clinical Neurophysiology Society examined the evidence on whether intraoperative SSEPs and MEPs predict adverse surgical outcomes. (6) Outcomes of patients with evoked potential (EP) changes were compared with those of patients without EP changes. To reduce bias, the only outcomes assessed were new paraparesis, paraplegia, and quadriplegia. Twelve studies met inclusion criteria and were reviewed. Results of the 4 Class I diagnostic studies showed that 16% to 40% of patients who had an EP change during IONM had paraparesis, paraplegia, or quadriplegia. There were no adverse events in patients without an EP change. The evidence review did not identify any studies that evaluated these outcomes in patients with IONM compared to patients without IONM. The review did identify 1 prospective study that found a significant positive relationship between the decision to monitor and better motor outcome.

Multimodal IONM

Authors of a study from a U.S. center reviewed records of 1121 patients with scoliosis treated at 4 pediatric spine centers between 2000 and 2004 and monitored with a multimodality technique. (7) Thirty-eight had recordings that met criteria for signal change. Of these, 17 showed suppression of the amplitude of transcranial electrical MEPs in excess of 65% without evidence of changes in SSEPs. In
9 of the 38 patients, the signal change was related to hypotension and was corrected with augmentation of the blood pressure. In the remaining 29 patients, the alert was related directly to a surgical maneuver (segmental vessel clamping and posterior instrumentation and correction). Nine of the 26 patients with an instrumentation-related alert woke with a transient motor and/or sensory deficit. Seven of these 9 patients presented solely with a motor deficit, which was detected by monitoring of MEPs in all cases. Two patients had only sensory symptoms. Sensory-evoked potentials (SEPs) failed to identify a motor deficit in 4 of the 7 patients and, when changes in SEPs occurred, they lagged behind changes in transcranial electric MEPs by an average of approximately 5 minutes.

Visual-evoked Potentials (VEPs)

Several articles from Asia describe potentially useful methods of utilizing intraoperative VEPs to assess the integrity of visual pathway structures, including optic nerves, in order to detect visual impairment before it is irreversible. (8, 9) More research is required to identify the role and utility of intraoperative VEPs.

Neurophysiologic Monitoring of Peripheral Nerves

In a 2011 report, Clarkson et al describe the use of intraoperative nerve recording for suspected brachial plexus root avulsion. (10) Included in this retrospective review were 25 consecutive patients who underwent intraoperative nerve recording during surgery for unilateral brachial plexus injury. Of 55 roots thought to be avulsed preoperatively, 14 (25%) were found to be intact with intraoperative nerve recording. Eleven of these were then used for reconstruction, of which 9 (82%) had a positive functional outcome.

A correlation between specific electromyogram (EMG) signals from motor cranial nerves and postoperative facial palsy was reported in a series of patients who underwent surgery on acoustic neuroma (n=24) or meningioma (n=6). (11) During surgery, direct electrical stimulation was used to ensure that the nerve bundle remained intact. EMG was recorded from muscles targeted by the facial, trigeminal, and lower cranial nerves and analyzed off-line. The occurrence of the A train (a sinusoidal, symmetrical sequence of high-frequency and low-amplitude signals) was identified in 19 patients, 18 of whom had postoperative facial nerve paresis. With 1 false positive and 3 false negative measurements, sensitivity and specificity were calculated at 86% and 89%, respectively. Intervention was not performed during the surgery.

Neurophysiologic monitoring of peripheral nerves has also been reported in patients undergoing orthopedic procedures including tibial/fibular osteotomies, hip arthroscopy for femoroacetabular impingement, and shoulder arthroplasty. (12-14)

Practice Guidelines and Position Statements

A 2012 position statement on electrophysiologic monitoring during routine spinal surgery by the American Association of Neurological Surgeons (AANS)/Congress of Neurological Surgeons (CNS) states that intraoperative electrophysiological monitoring during spinal surgery may assist in
diagnosing neurologic injury. (15) However, the AANS/CNS finds no evidence that such monitoring either 1) reduces the incidence of neurologic injury or 2) mitigates the severity of it. The position of the AANS/CNS is that routine use of intraoperative electrophysiologic monitoring is neither warranted nor recommended, although intraoperative electrophysiologic monitoring should be performed if the diagnostic information gained is of value, particularly in high-risk cases such as deformity, gross instability, navigation through or around peripheral nerves, or intramedullary procedures.

A 2013 position statement on somatosensory-evoked potentials (SSEPs) from the American Association of Neuromuscular & Electrodiagnostic Medicine (AANEM) states that intraoperative SEPs have demonstrated usefulness for monitoring of spinal cord, brainstem, and brain sensory tracts. (16) AANEM states that intraoperative SEP monitoring is indicated for selected spine surgeries in which there is a risk of additional nerve root or spinal cord injury. Indications for SEP monitoring may include, but are not limited to, complex, extensive, or lengthy procedures, and when mandated by hospital policy. However, intraoperative SEP monitoring may not be indicated for routine lumbar or cervical root decompression.

A 2005 guideline from the AANS/CNS on the performance of lumbar fusion for degenerative disease of the lumbar spine found insufficient evidence to recommend a treatment standard for intraoperative electrophysiologic monitoring. (17) The AANS/CNS provided a guideline recommendation for use of intraoperative SSEP or dermatomal sensory-evoked potential (DSEP) monitoring as an adjunct in those circumstances during instrumented lumbar spinal fusion procedures in which the surgeon desires immediate intraoperative information regarding the potential of a neurologic injury. The occurrence of a postoperative neurologic deficit is highly correlated with intraoperative changes in these monitoring modalities. An abnormal SSEP or DSEP during surgery, however, often does not correlate with a postoperative neurologic injury because of a high false positive rate. Intraoperative-evoked EMG recording was recommended as an option during lumbar spinal fusion surgery in those situations in which the operating surgeon desires immediate information regarding the integrity of the pedicle wall, as a normal-evoked EMG response is correlated with an intact pedicle wall. A normal-evoked EMG response is highly predictive of the lack of a neurologic injury. An abnormal EMG response during the surgical procedure may or may not be associated with a clinically significant injury.

In 2009 the American Clinical Neurophysiology Society (ACNS) published recommended standards for intraoperative neurophysiologic monitoring. (18) Guideline 11A includes the following statement (19):

The monitoring team should be under the direct supervision of a physician with training and experience in NIOM. The monitoring physician should be licensed in the state and privileged to interpret neurophysiologic testing in the hospital in which the surgery is being performed. He/she is responsible for real-time interpretation of NIOM data. The monitoring physician should be present in the operating room or have access to NIOM data in real-time from a remote location and be in communication with the staff in the operating room. There are many methods of remote monitoring however any method used must conform to local and national protected health information guidelines. The monitoring physician must be available to be in the operating room, and the specifics of this availability (i.e., types of surgeries) should be
decided by the hospital credentialing committee. In order to devote the needed attention, it is recommended that the monitoring physician interpret no more than three cases concurrently.

AAN published an assessment of IONM in 1990 with an evidence-based guideline update in 2012 by the AAN and the American Clinical Neurophysiology Society (ACNS). (6, 20) The 1990 assessment indicates that monitoring requires a team approach with a well-trained physician-neurophysiologist to provide or supervise monitoring. EEG monitoring is used during carotid endarterectomy or for other similar situations in which cerebral blood flow is at high risk. Electrocorticography from surgically exposed cortex can help to define the optimal limits of a surgical resection or identify regions of greatest impairment, while sensory cortex SSEPs can help to localize the central fissure and motor cortex. Auditory-evoked potentials, along with cranial nerve monitoring can be used during posterior fossa neurosurgical procedures. Spinal cord SSEPs are frequently used to monitor the spinal cord during orthopedic or neurosurgical procedures around the spinal cord, or cross-clamping of the thoracic aorta. EMG monitoring during procedures around the roots and peripheral nerves can be used to warn of excessive traction or other impairment of motor nerves. At the time of the 1990 assessment, MEPs were considered investigational by many neurophysiologists. The 2012 update, which was endorsed by the American Association of Neuromuscular and Electrodiagnostic Medicine, concluded that the available evidence supports IONM using SSEPs or MEPs when conducted under the supervision of a clinical neurophysiologist experienced with IONM. Evidence was insufficient to evaluate IOMN when conducted by technicians alone or by an automated device.

AAN published a model policy on principles of coding for intraoperative neurophysiologic monitoring (IOM) and testing in 2012. (21) The background section of this document provides the following information on the value of IOM in averting neural injuries during surgery:

1. Value of EEG Monitoring in Carotid Surgery. Carotid occlusion, incident to carotid endarterectomies, poses a high risk for cerebral hemispheric injury. EEG monitoring is capable of detecting cerebral ischemia, a serious prelude to injury. Studies of continuous monitoring established the ability of EEG to correctly predict risks of postoperative deficits after a deliberate, but necessary, carotid occlusion as part of the surgical procedure. The surgeon can respond to adverse EEG events by raising blood pressure, implanting a shunt, adjusting a poorly functioning shunt, or performing other interventions.

2. Multicenter Data in Spinal Surgeries. An extensive multicenter study conducted in 1995 demonstrated that IOM using SEP reduced the risk of paraplegia by 60% in spinal surgeries. The incidence of false negative cases, wherein an operative complication occurred without having been detected by the monitoring procedure, was small: 0.06%.

3. Technology Assessment of Monitoring in Spinal Surgeries. A technology assessment by the McGill University Health Center reviewed 11 studies and concluded that spinal IOM is capable of substantially reducing injury in surgeries that pose a risk to spinal cord integrity. It recommended combined SEP/MEP monitoring, under the presence or constant availability of a monitoring physician, for all cases of spinal surgery for which there is a risk of spinal cord injury.

4. Value of Combined Motor and Sensory Monitoring. Numerous studies of post-surgical paraparesis and quadriplegia have shown that both SEP and MEP monitoring had predicted
adverse outcomes in a timely fashion. The timing of the predictions allowed the surgeons the opportunity to intervene and prevent adverse outcomes. The two different techniques (SEP and MEP) monitor different spinal cord tracts. Sometimes, one of the techniques cannot be used for practical purposes, for anesthetic reasons, or because of preoperative absence of signals in those pathways. Thus, the decision about which of these techniques to use needs to be tailored to the individual patient’s circumstances.

5. Protecting the Spinal Cord from Ischemia during Aortic Procedures. Studies have shown that IOM accurately predicts risks for spinal cord ischemia associated with clamping the aorta or ligating segmental spinal arteries. IOM can assess whether the spinal cord is tolerating the degree of relative ischemia in these procedures. The surgeon can then respond by raising blood pressure, implanting a shunt, re-implanting segmental vessels, draining spinal fluid, or through other interventions.

6. Value of EMG Monitoring. Selective posterior rhizotomy in cerebral palsy significantly reduces spasticity, increases range of motion, and improves functional skills. Electromyography during this procedure can assist in selecting specific dorsal roots to transect. EMG can also be used in peripheral nerve procedures that pose a risk of injuries to nerves.

7. Value of Spinal Monitoring using SSEP and MEPs. According to a recent review of spinal monitoring using SSEP and MEPs by the Therapeutics and Technology Assessment Subcommittee of AAN and ACNS, IOM is established as effective to predict an increased risk of the adverse outcomes of paraparesis, paraplegia, and quadriplegia in spinal surgery (4 Class I and 7 Class II studies). Surgeons and other members of the operating team should be alerted to the increased risk of severe adverse neurologic outcomes in patients with important IOM changes (Level A).

Limitations on Coverage

To derive optimal benefits from this technology, it is incumbent on the IOM team to understand the limits of the technology, listed next.

- Use of Qualified Personnel IOM must be furnished by qualified personnel. For instance, the beneficial results of monitoring with SSEPs demonstrated by the 1995 multicenter study (Nuwer et al, 1995) showed fewer neurological deficits with experienced monitoring teams. While false positive events were significant in only 1% of cases, the negative predictive value for this technique was over 99%. Thus, absence of events during monitoring signifies and assures safety of the procedure. In general, it is recommended that the monitoring team strive to optimize recording and interpreting conditions such that:
  - A well-trained, experienced technologist, present at the operating site, is recording and monitoring a single surgical case; and
  - A monitoring clinical neurophysiologist supervises the technologist.

- Effects of the Depth of Anesthesia and Muscle Relaxation. The level of anesthesia may also significantly impact on the ability to interpret intraoperative studies; therefore, preoperative planning and continuous communication between the anesthesiologist and the monitoring team is expected.
• Recording Conditions. It is also expected that a specifically trained technologist or nonphysician monitorist, preferably with credentials from the American Board of Neurophysiologic Monitoring or the American Board of Registration of Electrodiagnostic Technologists (ABRET), will be in continuous attendance in the operating room, with either the physical or electronic capability for real-time communication with the supervising physician.

• Monitoring Necessity. Intraoperative monitoring is not medically necessary in situations where historical data and current practices reveal no potential for damage to neural integrity during surgery. Monitoring under these circumstances will exceed the patient’s medical need (Social Security Act (Title XVIII); Medicare Benefit Policy Manual).

• Communications. Monitoring may be performed from a remote site, as long as a well-trained technologist (see detail previous discussion) is in continuous attendance in the operating room, with either the physical or electronic ability for prompt real-time communication with the supervising monitoring physician.

• Supervision Requirements. Different levels of physician supervision apply to different kinds of IOM procedures. Code 95940 supervision require continuous physician monitoring in the operating room. Code 95941 supervision require continuous physician monitoring, which can be provided online or in the operating room.

The American Society of Neurophysiological Monitoring (ASNM) provides a 2013 practice guideline for the supervising professional on intraoperative neurophysiologic monitoring. (22) The ASNM 2013 position statement on intraoperative MEP monitoring includes the statement that MEPs are an established practice option for cortical and subcortical mapping and for monitoring during surgeries risking motor injury in the brain, brainstem, spinal cord or facial nerve. (23)

2008 Guidance from the United Kingdom’s National Institute for Health and Care Excellence (NICE) on intraoperative nerve monitoring during thyroid surgery finds no major safety concerns. (24) In terms of efficacy, IONM may be helpful in performing more complex operations such as reoperative surgery and operations on large thyroid glands. Therefore, it may be used with normal arrangements for consent, audit and clinical governance.

In 1999, the International Organization of Societies for Electrophysiological Technology (OSET) published guidelines for performing EEG and evoked potential monitoring during surgery. (25) Included in the guidelines are recommended standards for surgical monitoring personnel, technique and standards of safety, along with standards for monitoring SSEPs, auditory-evoked potentials, and EEG. The guidelines indicate that neuromonitoring may be useful during surgery that may affect spinal cord function (deformity correction, traumatic spinal fracture repair, tethered cord release, spinal cord mass removal), brainstem function (posterior fossa mass removal), brain function (carotid endarterectomy, aneurysm repair), and peripheral nerve function (pelvic fracture surgery). BAEPs can be utilized during neurosurgical procedures that involve the pons and the lower midbrain, and EEG monitoring can be useful for monitoring the brain when surgical procedures may potentially compromise blood perfusion to the brain or involve the cerebral cortex. EEG monitoring is described for carotid endarterectomy, intracranial aneurysm surgery, cardiac bypass surgery, electrocorticography, and the Wada test.
In 1993, the International Federation of Clinical Neurophysiology (IFCN) published a report on neuromonitoring during surgery. (26) The stated goals of neuromonitoring are the identification of new neurologic impairment early enough to allow prompt correction of the cause, prompt identification of new systemic impairment, to help a surgeon to identify uncertain or unrecognized tissue, identify the location of a lesion, provide reassurance to the surgeon during the course of an operation, and for high-risk patients. The report describes standard procedures for electrocorticography, EEG, auditory- and somatosensory-evoked potentials (SSEPs), and MEPs.

Summary

Intraoperative neurophysiologic monitoring (IONM) describes a variety of procedures that have been used to monitor the integrity of neural pathways during high-risk neurosurgical, orthopedic, and vascular surgeries. At the present time, it appears that monitoring of somatosensory-evoked potentials (SSEPs) and motor-evoked potentials (MEPs), particularly for spine surgery and open abdominal aorta aneurysm repairs, has broad acceptance though the evidence base consists mainly of observational studies. Therefore, intraoperative monitoring, which includes somatosensory-evoked potentials, motor-evoked potentials using transcranial electrical stimulation, brainstem auditory-evoked potentials (BAEPs), electromyogram (EMG) of cranial nerves, electroencephalogram (EEG), and electrocorticography (ECoG), may be considered medically necessary during spinal, intracranial, or vascular procedures.

More research is required to identify the role and utility of intraoperative visual-evoked potentials (VEPs); this is considered investigational. Due to the lack of U.S. Food and Drug Administration (FDA) approval, intraoperative monitoring of motor-evoked potentials using transcranial magnetic stimulation is considered investigational. Intraoperative EMG and nerve conduction velocity monitoring during surgery on the peripheral nerves is considered not medically necessary.

It should be noted that there is ongoing controversy about the utility of IONM in some surgical procedures. Most of the literature is from Europe and the United Kingdom, and, while many papers report the sensitivity and specificity of MEPs for predicting post-surgical neurological deficits, few papers report intraoperative interventions undertaken in response to information from monitoring. In a review, Malhotra and Shaffrey note that although MEP monitoring is considered to be safe, relative contraindications include epilepsy, cortical lesion, skull defect, proconvulsant medication, cardiac pacing, and implantable device. (27)

Medicare Coverage

Electroencephalographic (EEG) monitoring "may be covered routinely in carotid endarterectomies and in other neurological procedures where cerebral perfusion could be reduced. Such other procedures might include aneurysm surgery where hypotensive anesthesia is used or other cerebral vascular procedures where cerebral blood flow may be interrupted". (28) Coverage determinations for other modalities were not identified.
References

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28. Centers for Medicare and Medicaid Services. National Coverage Determination (NCD) for Electroencephalogalraphic Monitoring During Surgical Procedures Involving the Cerebral
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<tr>
<td>December 2011</td>
<td>New Policy</td>
<td>Policy updated with literature review; references added and reordered; policy statements unchanged.</td>
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<tr>
<td>March 2013</td>
<td>Update Policy</td>
<td>Policy updated with literature review, references 10-14, 16-18, 22, 24, and 25 added; policy statements unchanged.</td>
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**Keywords**

- EEG monitoring
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- Intra-operative monitoring
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- Motor-evoked potentials
- Sensory-evoked potentials
- Somatosensory-evoked potentials
- Visual-evoked potentials

This policy was approved by the FEP Pharmacy and Medical Policy Committee on September 12, 2014 and is effective October 15, 2014.

Signature on File

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