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Clinical UM Guideline

Subject:	**Intraoperative Neurophysiological Monitoring**		
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Status:	**New**	**Last Review Date:**	**11/07/2019**

Description

Intraoperative neurophysiological monitoring uses recordings of the nervous system's electrical response to the stimulation of specific neural pathways (e.g., visual, motor, auditory, general sensory evoked response studies) to obtain information on the functional integrity of pathways within the nervous system during an operative procedure. This information can assist in diagnosis of a pathological process, monitor response to therapies, identify anatomical distribution of a disease process or identify neurologic compromise. This document addresses the various types of evoked response studies and their use in intraoperative neurophysiological monitoring. The use of neural evoked response studies for purposes other than assistance during a surgical procedure is not addressed in this document.

Note: Please see the following related document(s) for additional information:

- **CG-MED-24 Electromyography and Nerve Conduction Studies (EMG/NCS)**
- **CG-MED-46 Electroencephalography and Video Electroencephalographic Monitoring**
- **CG-MED-50 Visual, Somatosensory and Motor Evoked Potentials**

Clinical Indications

Medically Necessary:

Intraoperative neurophysiological monitoring is considered medically necessary when ALL of the following are met:

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A. **The specific testing is used to monitor neural integrity during a spinal, neurologic, cranial, or vascular procedure that may compromise neurologic function; and**
B. **The specific testing is tailored to the clinical circumstances of the surgery. The following tests may be medically necessary when the neural pathway measured by the test is likely to be affected by the surgical procedure:**
   1. **Somatosensory-evoked potentials (SSEP);**
   2. **Brainstem auditory-evoked potentials (BAEPs);**
   3. **Electromyogram (EMG);**
   4. **Electroencephalogram (EEG);**
   5. **Electrocorticography (ECoG);**
   6. **Direct cortical stimulation;**
   7. **Nerve conduction velocity testing;**
   8. **Motor evoked potentials (MEP); and**
C. **The monitoring is ordered by the operating surgeon; and**
D. **The monitoring is set up and performed in the operating room by an independent technologist present at the operating site whose sole function is monitoring and transmission of data for a single case. The technologist is in continuous attendance in the operating room; and**
E. **A physician (e.g., neurophysiologist, neurologist) who is NOT a member of the surgical team, whose sole function is interpreting monitored data, performs real time monitored data interpretation; and**
F. **The surgical team (surgeon, anesthesiologist) and the monitoring team (technician, physician) have a direct, real-time communication regarding the individual's status based on data interpretation; and**
G. **The monitoring physician may work from a remote site only when an independent technologist is in continuous attendance in the operating room and has the capability for real-time communication with the supervising monitoring physician; and**
H. **The number of individuals monitored by the physician at one time should not exceed the requirements to provide adequate attention to each individual (generally 3 or fewer simultaneous cases).**

Not Medically Necessary:

The following services are considered not medically necessary in the following situations:

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- **The criteria above are not met; or**
- **Intraoperative neurophysiological monitoring of visual-evoked potentials; or**
- **Intraoperative neurophysiological vestibular evoked myogenic potential testing; or**
- **With the exception of EMG during pedicle screw stimulation, intraoperative neurophysiological monitoring used during routine spinal surgeries ~~lumbar or cervical laminectomy~~ in the absence of myelopathy or other complicating conditions that would create significant potential risk of damage to the nerve root, plexus (for example, anterior spine access through the psoas muscle) or spinal cord.**

Coding

The following codes for treatments and procedures applicable to this guideline are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement policy. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

CPT	
95829	**Electrocorticogram at surgery**
95940	**Continuous intraoperative neurophysiology monitoring in the operating room, one on one monitoring requiring personal attendance, each 15 minutes**
95941	**Continuous intraoperative neurophysiology monitoring, from outside the operating room (remote or nearby) or for monitoring of more than one case while in the operating room, per hour**
HCPCS	
G0453	**Continuous intraoperative neurophysiology monitoring, from outside the operating room (remote or nearby), per patient, (attention directed exclusively to one patient) each 15 minutes**
ICD-10 Procedure	
4A1004G-4A10X4G	**Monitoring of central nervous electrical activity, intraoperative [by approach; includes codes 4A1004G, 4A1034G, 4A1074G, 4A1084G, 4A10X4G]**

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4A1104G-4A11X4G	**Monitoring of peripheral nervous electrical activity, intraoperative [by approach; includes codes 4A1104G, 4A1134G, 4A1174G, 4A1184G, 4A11X4G]**

ICD-10 Diagnosis

All diagnoses

Discussion/General Information

Evoked response studies, when used during surgical procedures, monitor the nerves that are located at or pass through operative sites. The functional integrity of neurologic pathways is monitored for compromise due to significant ischemia or injury that might put the tested nerves or spinal cord at risk. Real-time intraoperative neurophysiological monitoring (IONM) can be performed with the data transmitted to an off-site monitoring center where a physician (e.g. neurophysiologist) provides interpretation and alerts the surgical team if the individual's neurological status is compromised.

The American Academy of Neurology (AAN), in its *Principles of Coding for Intraoperative Neurophysiologic Monitoring (IOM) and Testing* document (last updated in July 2018) stated that the beneficial results of IOM are realized under the following conditions in a hospital setting:

- **A well-trained, experienced technologist is present at the operating site recording and monitoring a single surgical case.**
- **A monitoring clinical neurophysiologist supervises the technologist.**
- **There should be preoperative anesthesia planning and continuous communication between the anesthesiologist and the monitoring staff.**
- **A specifically trained technologist or non-physician monitorist should be in continuous attendance in the operating room, with the capacity (physical or electronic) of real-time communication with the supervising physician.**
- **Monitoring may be performed from a remote site only when a specifically trained technologist or non-physician monitorist is in continuous attendance in the operating room and has either the physical or electronic ability for prompt real-time communication with the supervising monitoring physician.**

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Guidance on the number of cases monitored at a given time by a supervising physician is provided in the following section of the AAN principles of coding document:

> **The number of cases monitored at any one time will vary, but should not exceed the requirements for providing adequate attention to each. For example, a 2010 AAN survey of IOM practitioners shows that on average 90% of monitoring hours are spent monitoring three (3) or fewer simultaneous cases and that practitioners rarely monitor more than six (6) cases simultaneously (2010 AAN Survey of IOM Practitioners – unpublished).**

Evoked response studies are categorized according to the type of stimulation used:

Somatosensory-evoked potentials (SSEPs)
SSEPs are electrical waves that are generated by the response of sensory neurons to stimulation. Peripheral nerves (i.e., the median, ulnar or tibial nerve) are typically stimulated, but in some situations, the spinal cord may be stimulated directly. By stimulating the skin in various dermatomal areas, an SEP may also be recorded. This is called a dermatomal SEP or DSEP. The American Association of Electrodiagnostic Medicine's (AAEM, 1999) published guidelines: *Somatosensory Evoked Potentials: Clinical Uses* stated that, in many medical centers, SSEP monitoring during spinal surgery is standard practice and it is most commonly used in surgery for scoliosis and following spinal trauma. However, they noted that "intraoperative somatosensory evoked potentials monitoring is not of proven benefit for routine lumbar or cervical laminectomy or fusion".

In 2012, Nuwer and colleagues published an evidence review for a guideline from the American Academy of Neurology (AAN) and the American Clinical Neurophysiology Society (ACNS). The authors conducted a literature search for studies on the impact of IOM using SSEPs and/or transcranial motor-evoked potentials (MEPs) in individuals undergoing spinal surgery. A total of 12 studies were included in the review; all were case series. The studies consistently found that paraparesis, paraplegia and quadriplegia events occurred in IOM surgeries when there were evoked potential (EP) changes and none of these events occurred in IOM surgeries without EP changes. The authors concluded that IOM is effective for predicting an increased risk of adverse outcomes (paraparesis, paraplegia and quadriplegia) in individuals undergoing spinal surgery.

There are several meta-analyses on the diagnostic accuracy of SSEP for specific types of surgery. A meta-analysis by Nwachuku and colleagues (2015) identified 15 cohort studies on the diagnostic value of SSEP changes during carotid endarterectomy (CAE) for individuals with symptomatic carotid stenosis (CS). In a pooled analysis, changes in SSEPs had a mean specificity of 91% and a mean sensitivity of 58%. Individuals later found to have perioperative neurological deficits were 14 times more likely to have had changes in SSEPs during surgery.

Thurmula and colleagues (2016) evaluated studies on the diagnostic accuracy of SSEP during cerebral aneurysm clipping surgery. The authors identified 13 relevant prospective and retrospective cohort studies. The pooled sensitivity of SSEP for predicting postoperative neurological outcomes was 56.8% (95% confidence interval [CI], 44.1-68.6%) and the pooled specificity was 84.5% (95% CI, 76.3-90.3%). There was a pooled diagnostic odds ratio (DOR) for SSEP of 7.7 (95% CI, 5.1-11.8) suggesting that the odds for detecting a change in SSEP was 7 times higher in individuals with a postoperative neurological deficit than in those without a deficit.

In 2018, Azad and colleagues published a meta-analysis on the diagnostic utility of IONM for intramedullary spinal cord tumors. The authors identified 8 studies on SSEP monitoring, all of which were retrospective cohort studies. The pooled sensitivity for identifying postoperative deficits was 85% (95% CI, 75-91%) and the pooled specificity was 72% (95% CI, 57-83%). The pooled DOR for SSEP was 14.3 (95% CI, 5.47-37.3) indicating that the odds of detecting a change in SSEP was significantly higher in individuals with neurological deficits than in those without neurological deficits.

Motor-Evoked Potential Monitoring (MEP)
MEP evaluates motor pathways located in the anterolateral spinal tracts perfused by the anterior spinal artery. MEP utilizes electric or magnetic stimulation of the motor neural pathways in the brain or spinal cord. Electrical stimulation is accomplished by placement of surface or needle electrodes on the sites that innervate areas at risk during surgery. Magnetic stimulation utilizes a magnetic coil placed on the head over the motor cortex. The electromagnetic energy induces an electrical current within the brain, which in turn can stimulate the motor neurons.

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The American Society of Neurophysiological Monitoring (ASNM) published a position statement on intraoperative MEP (MacDonald, 2013). The document included a summary recommendation that intraoperative MEPs are an established option when done by appropriately qualified personnel for:

> **…localizing motor cortex, judging subcortical proximity to corticospinal tract fibers and monitoring motor pathways during surgical procedures that risk motor system injury in the brain, brainstem, spinal cord or facial nerve…**

The evidence level for the recommendation was based on Class II (non-randomized studies such as cohort studies and case series) and Class III (expert opinion, historical controls and case reports) evidence.

Several meta-analyses evaluating literature on the diagnostic accuracy of MEPs for specific indications have been published. A 2016 meta-analysis (Tanaka, 2016) identified 19 studies on MEP monitoring during thoracic or thoracoabdominal aortic aneurysm (TAA/TAAA) surgery. The authors found that MEP monitoring performed well for detecting postoperative paraplegia (pooled sensitivity: 89.1%, pooled specificity, 99.3%).

In 2017, Thirumala reviewed studies on diagnostic accuracy of transcranial MEPs for detecting neurological deficits during idiopathic scoliosis correction surgery. The authors identified 12 studies, 4 prospective cohort studies and 8 retrospective cohort studies. The pooled mean specificity for detecting a neurological deficit was 91% (95% CI, 34-100%) and the pooled mean specificity was 96% (95% CI, 92-98%). The pooled DOR was 250 (95% CI, 11-5767). This indicated a large increase in the odds of observing new motor deficits in individuals with significant changes in transcranial MEP changes during idiopathic scoliosis correction surgery compared to those without significant transcranial MEP changes,

A meta-analysis published by Azad and colleagues in 2018 addressed the diagnostic utility of IONM for intramedullary spinal cord tumors. The authors identified 12 retrospective cohort studies and 1 case-control study on MEPs for monitoring intramedullary spinal cord tumors. In a pooled analysis of data from these studies, the mean sensitivity for detecting postoperative deficits was 90% (95% CI, 84-94%) and a mean specificity of 82% (95% CI, 70-90%). The pooled DOR for MEP was 55.7 (95% CI, 26.3-119.1), which indicated a substantial increase in the odds of detecting neurological deficits in individuals with a change in MEP during spinal cord surgery compared to those without MEP changes.

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Brainstem auditory-evoked potentials (BAEPs)
BAEPs, also known as auditory brainstem evoked responses (ABR) are generated in response to auditory clicks and can define the functional status of the auditory nerve, pons and lower midbrain.

In 2008, the ASNM published a position statement on intraoperative monitoring of auditory evoked potentials (Martin, 2008). Based on Class III evidence (see above section on MEPs), the guideline panel stated that recording of ABR are of value during surgical procedures involving the brainstem and in assessing the function of the eighth nerve during select surgical procedures in the cerebellopontine angle.

Electromyogram (EMG) Monitoring and Nerve Conduction Velocity Measurements
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 adjacent to spinal nerve roots (including dorsal rhizotomy) and 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 the monitoring is done in the direction opposite to that of sensory-evoked potentials, but the purpose is similar – to verify that the neural pathway is intact.

Placement of pedicle screws is common during spinal surgery to provide stabilization. Triggered EMG (t-EMG) can used to detect misplacement of pedicle screws that might cause neural damage. A 2015 meta-analysis by Lee and colleagues identified 11 studies on the diagnostic accuracy of t-EMG in pedicle screw placement in the lumbar and thoracic spine. Overall, studies found high specificity (low false-positive [FP] rate) and low sensitivity of t-EMG for monitoring pedicle screw placement. For surgeries in the lumbar spine, t-EMG predicted misplaced pedicle screw placement with a pooled sensitivity of 0.55 (95% CI, 0.32-0.76) and a FP rate of 0.03 (95% CI, 0.01-0.09). In the thoracic spine, the pooled sensitivity was 0.41 (95% CI, 0.14-0.74) and the FP rate was 0.05 (95% CI, 0.02-0.09).

A guideline from the ASNM on IOM of segmental spinal nerve root function addressed electronically-triggered EMG monitoring of pedicle screw placement (Leppanen, 2005). The guideline included the following recommendation on electrical stimulation:

> **The use of electrical stimulation to help determine correct placement of spinal pedicle screws is a practice guideline that is of value for determining appropriate screw placement (Type C recommendation)**

A Type C recommendation was defined as a positive recommendation based on strong consensus and evidence provided by expert opinion, case reports and/or non-randomized comparative studies with historical controls.

Electroencephalogram (EEG) Monitoring

EEG monitoring has been widely used to monitor cerebral ischemia secondary to carotid cross clamping during a carotid endarterectomy. EEG monitoring may identify those individuals who would benefit from the use of a vascular shunt during the procedure in order to restore adequate cerebral perfusion. Conversely, shunts, which have an associated risk of iatrogenic complications, may be avoided in those individuals in whom the EEG is normal. Similarly, EEG is used in aneurysm clipping and other procedures where cerebral ischemia is a foreseeable risk. In cases with MEP stimulation, EEG is sometimes used to monitor for complications such as seizures due to the electrical brain stimulation.

Electrocorticography (ECoG) and Direct Cortical Stimulation

ECoG and Direct Cortical Stimulation are used to define the area of surgical resection. ECoG is a recording of the EEG directly from a surgically exposed cerebral cortex. ECoG 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. Direct cortical stimulation is used in craniotomies to help identify the functional cortex, most commonly for language and motor cortex or subcortical structures. Stimulation is delivered to each area to define where the cortical function is disrupted so that key functional areas are avoided during resection.

Visual-evoked potentials (VEPs)

VEPs 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 during surgery due to their sensitivity to anesthesia, temperature and blood pressure. A 2001 publication from the American Academy of Ophthalmology (AAO) stated that, in most cases VEPs are of limited clinical usefulness; use in surgery was not mentioned as one of the useful situations.

Vestibular Evoked Myogenic Potential (VEMP)
VEMP is described by Zhou and Cox (2006) as a biphasic response elicited by loud clicks or tone bursts recorded from the tonically contracted sternocleidomastoid muscle. This suggests that the VEMP is a vestibulocollic reflex whose afferent limb arises from acoustically sensitive cells in the saccule with signals conducted via the inferior vestibular nerve.

In 2017, the AAN published a practice guideline on cervical and ocular vestibular evoked myogenic potential testing (Fife, 2017). The guideline was based on a review of the literature. No RCTs were identified and the review included 9 controlled non-randomized studies. The guideline panel stated that cervical or ocular VEMP is possibly useful for distinguishing patients with superior canal dehiscence syndrome (SCDS) from controls, that evidence is insufficient to determine whether VEMP is useful for diagnosing vestibular neuritis or Ménière disease and that it not been demonstrated that VEMP is useful for diagnosing or managing vestibular migraine. There were no recommendations related to intraoperative use of VEMP.

Definitions

Auditory evoked potential: Evoked potentials generated in the central nervous system by sound.

Brainstem auditory evoked potentials (BAEPs): Evoked potentials measured in the brainstem in response to sound.

Electrocorticography (ECoG): Direct measurement of the electrical activity of the brain using electrodes placed on the cortex.

Electroencephalogram (EEG): Measurement of the electrical activity of the brain.

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Electromyogram (EMG): Measurement of electrical activity in muscle that has been electrically or neurologically stimulated.

Evoked potentials: Electrical activity evoked in one part of the nervous system through stimulation of another part of the nervous system.

Direct cortical stimulation: Application of stimulation directly to a surgically-exposed cortex.

Intraoperative: Occurring or performed during a surgical operation.

Motor evoked potentials (MEP): Electrical activity measurable in muscle in response to stimulation of the motor cortex area corresponding to that muscle.

Nerve conduction velocity test: Measurement of the speed at which a nerve impulse travels along a nerve following stimulation.

Somatosensory-evoked potentials (SSEP): Evoked potentials generated in the central nervous system by stimulation of peripheral sensory nerves.

Vestibular evoked myogenic potential (VEMP): Electrical activity in muscle (sternocleidomstoid for the cervical VEMP; inferior oblique for the ocular VEMP) generated in response to stimulation of the inner ear by sound.

Visual evoked potential (VEP): Evoked potentials generated in the central nervous system in response to light stimulus.

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Peer Reviewed Publications:

1. **American Association of Electrodiagnostic Medicine (AAEM). Somatosensory evoked potentials: Clinical uses. Muscle Nerve Suppl. 1999; 8:S111-S118.**
2. **Azad TD, Pendharkar AV, Nguyen V, et al. Diagnostic utility of intraoperative neurophysiological monitoring for intramedullary spinal cord tumors: Systematic review and meta-Analysis. Clin Spine Surg. 2018; 31(3):112-119.**
3. **Fife TD, Colebatch JG, Kerber KA, et al. Practice guideline: Cervical and ocular vestibular evoked myogenic potential testing: Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology. Neurology. 2017; 89(22):2288-2296.**
4. **Lee CH, Kim HW, Kim HR, et al. Can triggered electromyography thresholds assure accurate pedicle screw placements? A systematic review and meta-analysis of diagnostic test accuracy. Clin Neurophysiol. 2015; 126(10):2019-25.**
5. **Leppanen RE. Intraoperative monitoring of segmental spinal nerve root function with free-run and electrically triggered electromyography and spinal cord function with reflexes and F-responses. A position statement by the American Society of Neurophysiological Monitoring. J Clin Monit Comput. 2005; 19(6):437-61.**
6. **Macdonald DB, Skinner S, Shils J, et al. American Society of Neurophysiological Monitoring. Intraoperative motor evoked potential monitoring -a position statement by the American Society of Neurophysiological Monitoring. Clin Neurophysiol. 2013; 124(12):2291-2316.**
7. **Martin WH, Stecker MM. ASNM position statement: intraoperative monitoring of auditory evoked potentials. J Clin Monit Comput. 2008; 22(1):75-85.**
8. **Nuwer MR, Emerson RG, Galloway G, et al. Evidence-based guideline update: intraoperative spinal monitoring with somatosensory and transcranial electrical motor evoked potentials: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology and the American Clinical Neurophysiology Society. Neurology. 2012; 78(8):585-589.**
9. **Nwachuku EL, Balzer JR, Yabes JG, et al. Diagnostic value of somatosensory evoked potential changes during carotid endarterectomy: a systematic review and meta-analysis. JAMA Neurol. 2015; 72(1):73-80.**
10. **Tanaka Y, Kawaguchi M, Noguchi Y, et al. Systematic review of motor evoked potentials monitoring during thoracic and thoracoabdominal aortic aneurysm open repair surgery: a diagnostic meta-analysis. J Anesth. 2016; 30(6):1037-1050.**

11. **Thirumala PD, Crammond DJ, Loke YK, et al. Diagnostic accuracy of motor evoked potentials to detect neurological deficit during idiopathic scoliosis correction: a systematic review. J Neurosurg Spine. 2017; 26(3):374-383.**
12. **Thirumala PD, Udesh R, Muralidharan A, et al. Diagnostic value of somatosensory-evoked potential monitoring during cerebral aneurysm clipping: A systematic review. World Neurosurg. 2016; 89:672-80.**
13. **Zhou G, Cox LC. Vestibular evoked myogenic potentials: history and overview. Am J Audiol. 2004; 13(2):135-143.**

Government Agency, Medical Society, and Other Authoritative Publications:

1. **American Academy of Neurology. Model coverage policy: Principles of coding for intraoperative neurophysiologic monitoring (IOM) and testing. Last updated July 2018. Available at: https://www.aan.com/siteassets/home-page/tools-and-resources/practicing-neurologist--administrators/billing-and-coding/model-coverage-policies/16iommodelpolicy_tr.pdf. Accessed October 14, 2019.**
2. **Fishman GA, Birch DG, Holder GE, et al. Electrophysiologic Testing in Disorders of the Retina, Optic Nerve, and Visual Pathway. 2nd ed. Ophthalmology Monograph 2. San Francisco: American Academy of Ophthalmology; 2001.**

Websites for Additional Information

1. **American Academy of Neurological Surgery (AANS). Neurosurgical conditions and treatments. Available at: https://www.aans.org/en/Patients/Neurosurgical-Conditions-and-Treatments. Accessed October 14, 2019.**

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Vestibular Evoked Myogenic Potentials
Visual Evoked Potentials

The use of specific product names is illustrative only. It is not intended to be a recommendation of one product over another, and is not intended to represent a complete listing of all products available.

History

Status	Date	Action
New	11/07/2019	Medical Policy & Technology Assessment Committee (MPTAC) review. Initial document development.

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