Corporate Medical Policy
Intraoperative Neurophysiologic Monitoring (IONM)

Description of Procedure or Service

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.

Evoked potential monitoring includes somatosensory evoked potentials (SSEP), brainstem auditory evoked potentials (BAEP), motor evoked potentials (MEP), and visual evoked potentials (VEP). Electromyography (EMG) also is used extensively during operative cases. Scalp electroencephalography (EEG) provides data for analysis in SSEP, BAEP, and VEP. Scalp EEG also can be used to monitor cerebral function during carotid or other vascular surgery. In addition, EEG recorded directly from the pial surface, or electrocorticography (ECoG), is used to help determine resection margins for epilepsy surgery, and to monitor for seizures during electrical stimulation of the brain carried out while mapping cortical function.

Benefit Application

This medical policy relates only to the services or supplies described herein. Please refer to the Member’s Benefit Booklet for availability of benefits. Guidance on other uses of evoked potentials and/or electromyography, is not found in this policy; this document is limited to the use of such procedures for the purpose of intraoperative monitoring.

Policy Statement

GEHA will provide coverage for intraoperative neurophysiologic monitoring when it is determined to be medically necessary because the medical criteria and guidelines within this policy have been demonstrated.

When Intraoperative Neurophysiologic Monitoring is covered

Intraoperative neurophysiologic monitoring, by any covered modality, will only be covered for the specific indications identified in this policy when ALL of the following tenants of clinical management have been demonstrated:

A. A specially trained physician or a certified professional practicing within the scope of their license, who is not a member of the surgical team, contemporaneously interprets the intraoperative evoked potentials during the operation; and
B. The evoked potential monitoring is performed in the operating room by dedicated trained technician; and
C. The clinician who performs the interpretation may do so remotely, but must provide direct, immediate communication of intraoperative evoked potential results to the technician and surgeon during the operation.

**GEHA considers intra-operative electromyographic (EMG) monitoring medically necessary for the following indications when the required tenants of clinical management have been demonstrated:**

A. Surgical excision of neuromas of the facial nerve
B. Surgery for cholesteatoma, including mastoidotomy or mastoidectomy
C. Surgery for acoustic neuroma, congenital auricular lesions, or cranial base lesions
D. Vestibular neurectomy for Meniere's disease
E. Microvascular decompression of the facial nerve for hemifacial spasm
F. During selective dorsal rhizotomy
G. Brachial plexus surgery
H. Cauda equine tumor
I. Nerve root tumor (schwannoma)
J. Vestibular schwannoma surgery
K. Tethered cord release
L. Excision of neuromas of:
   1. Abducens nerve
   2. Glossopharyngeal nerve
   3. Hypoglossal nerve
   4. Oculomotor nerve
   5. Recurrent laryngeal nerve
   6. Spinal accessory
   7. Superior laryngeal nerve
   8. Trochlear nerve

**GEHA considers intra-operative somatosensory evoked potentials (SSEPs) performed either alone, or in combination with motor evoked potentials (MEPs) as medically necessary for monitoring the integrity of the spinal cord to detect adverse changes before they become irreversible during certain spinal, intracranial, or vascular procedures including the following:**

**Spinal Surgeries:**

A. Correction of scoliosis or deformity of the spinal cord involving traction on the cord
B. Decompression of the spinal cord where function of the spinal cord is at risk
C. Removal of spinal cord tumors
D. Surgery as a result of traumatic injury to the spinal cord
E. Surgery for arteriovenous (AV) malformation of the spinal cord

**Intracranial Surgeries:**
A. Chiari malformation surgery
B. Correction of cerebral vascular aneurysms (e.g., cerebral aneurysm clipping)
C. Deep brain stimulation
D. Endolymphatic shunt for Meniere's disease
E. Microvascular decompression of cranial nerves (e.g., optic, trigeminal, facial, auditory nerves)
F. Oval or round window graft
G. Removal of cavernous sinus tumors
H. Removal of tumors that affect cranial nerves
I. Resection of brain tissue close to the primary motor cortex and requiring brain mapping
J. Resection of epileptogenic brain tissue or tumor
K. Surgery as a result of traumatic injury to the brain
L. Surgery for intracranial AV malformations
M. Surgery for intractable movement disorders
N. Vestibular resection for vertigo

Vascular Surgeries:

A. Arteriography, during which there is a test occlusion of the carotid artery
B. Circulatory arrest with hypothermia (does not include surgeries performed under circulatory bypass such as CABG, and ventricular aneurysms)
C. Distal aortic procedures, where there is risk of ischemia to the spinal cord
D. Surgery of the aortic arch, its branch vessels, or thoracic aorta, including carotid artery surgery (e.g., carotid endarterectomy), when there is risk of cerebral ischemia

GEHA considers that intra-operative somatosensory evoked potentials (SSEPs) performed either alone, or in combination with motor evoked potentials (MEPs) may be medically necessary for monitoring the integrity of the recurrent laryngeal nerve in patients undergoing:

High-risk thyroid or parathyroid surgery, including:
A. Total thyroidectomy
B. Repeat thyroid or parathyroid surgery
C. Surgery for cancer
D. Thyrotoxicosis
E. Retrosternal or giant goiter
F. Thyroiditis

Anterior cervical spine surgery associated with any of the following increased risk situations:
A. Prior anterior cervical surgery, particularly revision anterior cervical discectomy and fusion, revision surgery through a scarred surgical field, reoperation for pseudarthrosis or revision for failed fusion
B. Multilevel anterior cervical discectomy and fusion
C. Pre-existing recurrent laryngeal nerve pathology, when there is residual function of the recurrent laryngeal nerve.

When Intraoperative Neurophysiologic Monitoring is not covered
GEHA considers intra-operative EMG monitoring experimental/investigational for the following indications, including but not limited to:

A. During spinal surgery (including for anterior cervical, except as noted above) because there is insufficient evidence that this technique provides useful information to the surgeon in terms of assessing the adequacy of nerve root decompression, detecting nerve root irritation, or improving the reliability of placement of pedicle screws at the time of surgery (Garces, J. et. al., 2014).
B. During laryngeal nerve monitoring during parathyroid and thyroid surgery, except as noted above (Hermann, M., Hellebart, C., & Freissmuth, M., 2004).
C. During hip replacement surgery (Hesper, et. al., 2017).
D. During decompression, neurectomy, radiosurgery or rhizotomy of the trigeminal nerve (Bajwa, Z., Ho, C., & Khan, S., 2015).

GEHA considers intra-operative EEG monitoring experimental/investigational for the following indications, including but not limited to:

A. Intraoperative EEG for open-heart surgery (Gelinas, J. et. al., 2013).
B. All other indications (e.g., prediction of post-operative delirium)

GEHA considers intra-operative SSEPs with or without MEPs experimental/investigational for indications not listed above including, but not limited to:

A. Intraoperative BAER during stapedectomy, tympanoplasty and ossicle reconstruction;
B. Intraoperative MEP during implantation of a spinal cord stimulator;
C. Intraoperative neuromonitoring during adjustment of vertical expandable prosthetic titanium rib;
D. Intraoperative saphenous nerve somatosensory evoked potential for monitoring the femoral nerve during trans-psoas lumbar lateral interbody fusion;
E. Intraoperative SSEP of the facial nerve for submandibular gland excision or parotid gland surgery, during hip replacement surgery, implantation of a spinal cord stimulator, off-pump coronary artery bypass surgery, and for thyroid surgery and parathyroid surgery
F. Intraoperative SSEP, with or without MEPs, for cochlear implantation, decompression of the trigeminal nerve, implantation of vagus nerve stimulator, monitoring spinal injections (e.g., epidural injections, facet joint, interlaminar and transforminal epidural), open reduction internal fixation (ORIF) of the finger, radiofrequency ablation of facet medial branch, rotator cuff repair, or wrist arthroscopy repair;
G. Intraoperative visual evoked potentials (e.g., for pituitary surgery, during intra-cranial surgery for arterio-venous malformation);

GEHA considers intraoperative neurophysiologic monitoring of the recurrent laryngeal nerve during anterior cervical spine surgery not meeting the criteria above or during esophageal surgeries to be investigational.

GEHA considers EMG monitoring and neuromuscular junction testing during spinal surgery (including anterior cervical procedures) to be experimental and investigational.
GEHA has determined that intra-operative evoked potential studies have no proven value for lumbar surgery below (distal to) the end of the spinal cord; the spinal cord ends at L1-L2.

GEHA considers intraoperative monitoring of motor-evoked potentials using transcranial magnetic stimulation investigational.

GEHA considers intraoperative EMG and nerve conduction velocity monitoring during surgery on the peripheral nerves not medically necessary.

Policy Guidelines

Intraoperative monitoring typically is done in the operating room by a technician, with a physician as a remote backup. In some operating rooms there is a central physician monitoring room, where a physician may simultaneously monitor several cases. Constant communication between surgeon, neurophysiologist, and anesthetist is required for safe and effective intraoperative neurophysiologic monitoring.

IONM codes are reported based upon the time spent monitoring and not on the number of tests performed or parameters monitored. In addition, time spent monitoring excludes preparation, administration and interpretation times for baseline studies. Time spent performing or interpreting the baseline neurophysiologic studies should not be counted as intraoperative monitoring; these are separately reportable procedures.

Operating rooms typically have equipment that emits electromagnetic interference, which is greatest at the frequency of alternating current (60 Hz in the United States). It is recognized that such interference can impact the data obtained via neurophysiologic monitoring and appropriate steps by the responsible facility to mitigate the impact of this phenomenon on clinical outcomes are required.

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

“The monitoring team should be under the direct supervision of a physician with training and experience in NIOM (Neurophysiologic Intraoperative Monitoring). 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.”

American Board of Registration of Electroencephalographic and Evoked Potential Technologists (ABRET) has established guidelines for proper credentialing of the IONM professional. Although there are a number of different pathways, the candidate must have performed at least 150 surgical monitoring cases, passed a written examination, and hold either a bachelor’s degree or another credential in neurodiagnostics such as the R.EEG.T or R.EP.T (registered EEG or EP technologist). Gertsch et. al.
(2019) go on to outline the responsibilities of the IONM-P: In order to optimize patient care and safety, the IONM-Physician must remain continuously available to perform intraoperative responsibilities in real time throughout the procedure. Retrospective, or “after-the-fact” interpretation and reporting, is of negligible benefit to the patient or the surgeon. The IONM-Physician:

1. Supervises all technical aspects of IONM to ensure overall patient safety and quality of care.

2. Communicates and collaborates with other members of the patient care team

3. Interprets IONM data:
   
   (a) Evaluates the quality and consistency of baseline data and identifies abnormalities in the context of known variables.

   (b) Evaluates IONM data in the context of the procedure and takes into account patient vitals, imaging and labs when available and appropriate.

   (c) Evaluates and interprets data obtained from topographical/neuro-navigation studies.

4. Develops a differential diagnosis:

   (a) Determines the significance of changes from baseline data. To the extent possible, determines if changes are related to iatrogenic injury, anesthetic effects, physiological variables, patient positioning, technical factors, or a combination of these.

   (b) Recommends assessment technique(s) most appropriate to answer anatomic, functional, or prognostic questions related to specific neural structures.

5. Provides input to the patient care team to help develop and execute a plan of therapeutic intervention to recover neural function when an adverse alteration in IONM data presents.

The IONM technician is responsible for collaborating with the IONM Physician; relaying data that may indicated a need for intervention.

In 2013, The American Society of Neurophysiological Monitoring released a position statement recommending specific guidelines for IONM including medications to use, wave length specifications and qualifications for personnel.

The American Academy of Neurology concluded that IONM is established as effective for predicting increased risk of adverse outcomes such as paraparesis, paraplegia and quadriplegia during spinal surgery. Surgeons and other members of the operating team should be alerted to the increased risk of severe adverse neurological outcomes in patients with important IONM changes. Furthermore, there was insufficient evidence to evaluate IOM conducted by automated devices or technicians without the supervision of a clinical neurophysiologist experienced with IONM.

American Association of Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS) (2014): The position of the AANS/CNS is that IOM should be performed in procedures when the operating surgeon feels that the diagnostic information is of value. Such procedures include: deformity correction, spinal instability, spinal cord compression, intradural spinal cord lesions, and navigating in proximity to peripheral nerves or roots. AANS/CNS also recommends the use of spontaneous and
evoked EMG for minimally invasive lateral retroperitoneal transpsoas approaches to the lumbar spine, and may also be of utility during pedicle screw insertion.

**Physician documentation**

A. The medical record must contain evidence that fully supports the medical necessity criteria listed within this policy for IONM. This documentation includes, but is not limited to, relevant medical history, physical examination, the anatomic location of the planned surgical procedure, the rationale for the location and modalities to be monitored, and results of pertinent diagnostic tests or procedures.

B. Operative report (Post-procedure)

C. Intraoperative neurophysiologic monitoring report (Post-procedure)

D. Intraoperative neurophysiologic monitoring should not be reported by the physician performing an operative or anesthesia procedure since it is typically included in a global package.

**Background**

The principal goal of intraoperative neurophysiologic monitoring (IONM) is the identification of nervous system impairment on the assumption that prompt intervention will prevent permanent deficits. Correctable factors at surgery include circulatory disturbance, excess compression from retraction, bony structures, hematomas, or mechanical stretching.

Sensory-evoked potential describes the responses of the sensory pathways to sensory or electrical stimuli. Intraoperative monitoring of sensory-evoked potentials is used to assess the functional integrity of central nervous system (CNS) pathways during surgeries that put the spinal cord or brain at risk for significant ischemia or traumatic injury. The basic principles of sensory-evoked potential 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. Sensory-evoked potentials can be further categorized by the type of stimulation used: Somatosensory-evoked potentials (SSEP), Brainstem auditory-evoked potentials (BAEP) and Visual-evoked potentials (VEP) (Liem & Benbis, 2016).

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. Motor evoked potentials, especially when induced by magnetic stimulation, can be affected by anesthesia.

Transcranial motor evoked potentials MEP involve applying a train of high-voltage stimuli to electrodes on the surface of the head to activate motor pathways and produce either a motor contraction (muscle MEP) or a nerve action potential (D-wave) that can be recorded. This process can be performed in the awake patient (Stecker, M., 2012).

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 cranial or peripheral nerves, e.g., to identify the extent of nerve damage prior to nerve grafting or during resection of tumors. In addition,
such techniques may be used during procedures around nerve roots and/or peripheral nerves to assess for excessive traction or other impairment. In these procedures, monitoring is done in the direction opposite that of sensory-evoked potentials, but this still supports verification that the neural pathway is intact.

Electroencephalogram (EEG) monitoring is also employed as a mode of monitoring neural function during certain types of surgery. This includes use of intraoperative scalp monitoring of electroencephalogram activity, as well as grid monitoring or electrocorticography (ECoG). ECoG is recording of the EEG directly from a surgically exposed cerebral cortex and is primarily used to assess the sensory cortex and map areas for surgical resection.

Brainstem auditory evoked potentials (BAEP) record cortical responses to auditory stimuli. This allows monitoring of the function of the entire auditory pathway including acoustic nerve, brain stem, and cerebral cortex. Other terms for this technique include brainstem auditory evoked responses (BAER), auditory evoked potentials (AEP), and auditory brainstem responses (ABR).

Visual evoked potentials (VEP) have been performed successfully to aid in the monitoring of visual function during surgery in the hope of detecting visual impairment before it is irreversible. It has potential usefulness in assessing integrity of visual pathway structures including optic nerves; however, it cannot detect the presence of visual field defects. Intraoperative use of this technique is still in its infancy; further work is required to determine its full clinical utility (Liem & Benbis, 2016).

**Surgery Specific IONM**

**Facial/acoustic**

Electromyographic monitoring of the facial nerve (7th CN) is used to predict post-operative facial function after skull base surgery, which is associated with considerable risk to the functioning of the cerebral hemispheres, the brain stem and the CNs. This risk is due to problems associated with maintaining an adequate blood flow while exposing and removing the tumor, as well as direct or indirect trauma to the brain, perineural tissues and CNs (Stecker, M., 2012).

**Acoustic Neurinomas**

A study done by Nabhan et. al. (2005) to evaluate the influence of intraoperative monitoring on the function of the facial nerve after surgical treatment of acoustic neurinomas, classified according to the grading system of Stennert. One hundred thirty patients were divided into two groups. The first group underwent surgery without intraoperative facial monitoring; the second group included intraoperative facial monitoring. Concerning degree of paresis, preoperatively there was no statistically significant difference between the two groups. Despite structural preservation of the facial nerve, postoperative deterioration of its function was observed, which consecutively improved postoperatively. Postoperatively, the mean degree of paresis increased to 4.4±3.0 in group 1 and 2.4±2.3 in group 2. For better understanding of the role of intraoperative monitoring, investigation of the outcome of patients with acoustic
neurinomas who underwent surgery continued over the following 6 months postoperatively. At that time, function improved by 4.1±3.2 (group 1) and 2.0±2.3 (group 2). Intraoperative monitoring of the facial nerve was a significant factor for better postoperative function in patients undergoing microsurgical excision of neurinomas.

Schick et. al. (2013) discuss the complications that may be associated with surgery of the middle ear and lateral skull base. Preservation of facial nerve function is of outstanding importance in ear and lateral skull base surgery, as facial nerve palsy has debilitating functional and aesthetic consequences for the patient. During surgery, facial nerve function is most commonly observed by means of electromyographic (EMG) monitoring. Furthermore, the auditory nerve is controlled via the recording of auditory brainstem responses (ABRs) during procedures at the internal auditory canal.

**Vestibular Neurotomy in Meniere’s disease**

Salvinelli et. al. (2018) examined the use of IONM during surgery to correct selective vestibular neurotomy in Meniere’s disease. In all cases, intraoperative neurophysiological monitoring and direct stimulation of nervous fibers allowed the selective identification of the facial and cochlear nerve. The modern endoscopic technique and the intraoperative advanced neuromonitoring seem to be able to allow a precise, complete, and very selective vestibular neurotomy, preserving at the same time, the cochlear and facial nerve functions. A high success rate is due to the completeness of the vestibular nerve deafferentation of almost all its fibers.

**Microvascular Decompression Surgery for Hemifacial Spasm**

Hemifacial spasm (HFS) is due to the vascular compression of the facial nerve at its root exit zone (REZ). Microvascular decompression (MVD) of the facial nerve near the REZ is an effective treatment for HFS. In MVD for HFS, intraoperative neurophysiological monitoring (IONM) has two purposes. The first purpose is to prevent injury to neural structures such as the vestibulocochlear nerve and facial nerve during MVD surgery, which is possible through IONM of brainstem auditory evoked potential and facial nerve electromyography (EMG). The second purpose is the unique feature of MVD for HFS, which is to assess and optimize the effectiveness of the vascular decompression. The purpose is achieved mainly through monitoring of abnormal facial nerve EMG that is called as lateral spread response (LSR) and is also partially possible through Z-L response, facial F-wave, and facial motor evoked potentials. Based on the information regarding IONM mentioned above, MVD for HFS can be considered as a more safe and effective treatment (Park, S.K., Joo, B.E. & Park, K., 2019).

**Parotidectomy**

In a study by Graciano, et. al. (2018), facial nerve dysfunction after superficial parotidectomy with or without continuous intraoperative electromyographic neuromonitoring was evaluated. It was concluded that the incidences of immediate and late facial nerve dysfunction were similar between patients with benign parotid tumors.
subjected to superficial parotidectomy with or without continuous intraoperative electromyographic neuromonitoring. However, immediate facial dysfunction was more severe among the non-monitored patients.

**Cholesteatoma**

Facial paralysis can occur after surgery for cholesteatoma. The risk of facial nerve injury is great when the nerve is not covered by its normal bony Fallopian canal.

A study by Selesnick et al. (2001) strived to identify the incidence of facial nerve dehiscence in patients undergoing surgery for cholesteatoma. Results In 33% of the total procedures analyzed, 30% of the initial procedures, and 35% of the revision procedures, the patients were found to have facial nerve bony dehiscence. The dehiscence was present in the tympanic portion of the facial nerve in the vast majority of patients. Of the 97% of patients with normal preoperative facial nerve function, all retained normal function postoperatively. Findings suggest that surgeons should be highly vigilant when dissecting near the facial nerve. Intraoperative facial nerve monitoring has been shown to be of value in facial nerve preservation during acoustic neuroma resections, and may have a role during surgery for cholesteatoma.

**Spinal**

Methods to intra-operatively monitor spinal cord function have been employed to minimize risks during spinal surgery. These neurophysiological techniques include SSEP, dermatosensory evoked potentials (DSEP), and motor evoked potentials (MEP). The main objective of intra-operative neurophysiological monitoring of spinal cord or nerve root function is to identify induced neurophysiological alterations so that they can be detected as they occur and corrected during surgery; thus avoiding post-surgical complications such as myelopathy or radiculopathy, as well as permanent injury (Ney et. al., 2015).

In a retrospective analysis of 213 patients who underwent IONM with EMG and SSEP during thoracolumbar spinal surgery, it was determined that intraoperative electromyographic activation has a high sensitivity for the detection of a new postoperative neurologic deficit but a low specificity. In contrast, somatosensory-evoked potentials have low sensitivity but high specificity. Combined intraoperative neurophysiologic monitoring with electromyography and somatosensory-evoked potentials is helpful for predicting and possibly preventing neurologic injury during thoracolumbar spine surgery (Gunnarsson et. al., 2004).

In 2010, Fehlings et. al. performed a systematic review of the literature to determine whether IONM is able to sensitively and specifically detect intraoperative neurologic injury during spine surgery and to assess whether IONM results in improved outcomes for patients during these procedures. Based on strong evidence that multimodality intraoperative neuromonitoring is sensitive and specific for detecting intraoperative neurologic injury during spine surgery, it is recommended that the use of multimodality intraoperative neuromonitoring be considered in spine surgery where the spinal cord or nerve roots are deemed to be at risk, including procedures involving deformity correction and procedures that require the placement of instrumentation.
Trauma or Tumors

During spinal cord surgery for trauma or tumors, somatosensory evoked potentials (SEPs) are usually elicited by stimulating the median nerve at the wrist or the posterior tibial nerve at the ankle and recording the resultant evoked potential with a scalp electrode. Preoperative and intraoperative SEPs are compared, so each patient serves as his or her own control. A 50% decrease in amplitude of the signal or a 10% increase in latency time for signal conduction is considered a critical event requiring intervention by the surgeon or anesthesia team. SEPs are now frequently used in combination with other modes of continuous monitoring, such as motor evoked potentials (MEPs), to provide more information than SEPs alone. During procedures in patients with acute cord trauma or spinal cord tumors, the combined use of SEPs and MEPs is usual, since either the somatosensory or motor pathways may be injured. Combined monitoring modalities, multimodal intraoperative monitoring (MIOM), allow the surgeon to be more comfortable in proceeding with surgical repair or an aggressive tumor resection. However, monitoring does not replace meticulous surgical technique and knowledge (Hayes Health, 2012).

Brachial Plexus

In an examination of a case study relating to IONM for brachial plexus neurolysis during delayed fixation of a clavicular fracture with thoracic outlet syndrome, Bradley, et. al. (2018) determined that intraoperative neuromonitoring is a useful tool for minimizing the risk of additional brachial plexus injury and determining the adequacy of neural decompression during delayed open reduction and internal fixation of clavicular fractures with fracture-callus-induced brachial plexus compression.

In support of IONM use during brachial plexus surgery, Huang et. al. (2019) analyzed one hundred thirty-seven robotic transaxillary surgeries using SSEP monitoring performed on 123 patients. Seven patients developed significant changes, with an average SSEP amplitude reduction of 73% ± 12% recorded at the signals' nadir. Immediate arm repositioning resulted in recovery of signals and complete return to baseline parameters in 14.3 ± 9.2 minutes. There was no difference in age or body mass index between cases with and without SSEP change. Operative time was shorter for patients with significant SSEP change. There were no postoperative positional brachial plexus injuries. It was concluded that SSEP is a novel, safe, and reliable tool in detection of position-related brachial plexus neuropathy. Intraoperative monitoring using SSEP can play a vital role in early recognition and prevention of injury during robotic transaxillary surgery.

Conus medullaris and cauda equina

Two basic methodologies of intraoperative neurophysiological testing are utilized during surgery in the lumbosacral spinal canal. Mapping techniques help identify functional neural structures, namely, nerve roots and their respective spinal levels. Monitoring is referred to as the technology to continuously assess the functional integrity of pathways and reflex circuits. Electromyographic activity can be continuously observed during
surgery, and monitoring concepts developed in cranial nerve surgery may be used in the cauda equina as well (Kothbauer & Deletis, 2010).

**Schwannoma**

Sasaki, et. al. (2018) researched the use of motor evoked potential during the surgical enucleation of peripheral nerve schwannoma. Postoperative neurological deficit occurred in 22% of patients, which is similar to that of previous reports. The cause of postoperative neurological deficit in schwannoma remains unclear, although several mechanisms have been proposed, including preoperative nerve compression by the tumor, mechanical nerve injury during surgery, or ischemia of the nerve associated with the surgical procedure. Although postoperative neurological symptoms in patients with peripheral schwannoma are transient in the majority cases, it can be a problem in terms of patient satisfaction with the surgery.

In conclusion, the study examined the utility of MEP as a perioperative nerve monitoring technique during the enucleation of peripheral nerve schwannomas. Decreased blood flow caused by the pneumatic tourniquet was observed to result in a decrease in MEP. Although MEP alone was not able to predict postoperative transient sensory or motor deficits following the enucleation of schwannoma, the combination of MEP with other methods of neurological monitoring may improve the accuracy of nerve monitoring and should be investigated in future studies.

**Tethered Cord**

A study by Hoving et. al. (2011) examined the value of IONM in tethered cord surgery. All patients were diagnosed with a tethered cord (TC) due to spinal dysraphism. A high-risk group (HRG) was determined consisting of 40 patients with a lipomyelomeningocele and/or a split cord malformation sometimes in combination with a tight filum terminale. The surgical procedure was a detethering operation in all cases performed by a single surgeon during a 9-year period (1999–2008). A standard set-up of IONM was used in all patients consisting of motor-evoked potentials (MEP) evoked by transcranial electrical stimulation (TES) and electrical nerve root stimulation. In young patients, conditioning stimulation was applied in order to improve absent or weak MEPs. The results showed that IONM responses could be obtained in all patients. Postoperative deterioration of symptoms was found in two patients of whom one patient belonged to the HRG. Mean maximal follow-up of all 65 patients was 4.6 years (median 4.1 years). Long-term deterioration of symptoms was found in 6 of 65 patients with a mean follow-up of 5 years (median 5.3 years). It was concluded that the use of IONM is feasible in all tethered cord patients. The identification of functional nervous structures and continuous guarding of the integrity of sacral motor roots by IONM may contribute to the safety of surgical detethering.

**Cervical Spine**

Spitz30 stated that although advances have been made in surgical technique and IOM, the rate of post-operative C5 palsy remains the same. These researchers attempted to
define characteristics which may predict risk of developing post-operative C5 palsy. Retrospective chart review identified 644 patients undergoing cervical procedures. Anterior cervical disectomy and fusion was performed in 456, anterior cervical corpectomy and fusion (ACCF) in 78, posterior laminectomy and fusion (PLF) in 106, and posterior open-door laminoplasty in 4 patients. All patients had neurophysiologic monitoring (SSEP, spontaneous EMG, and/or MEP). Post-operative C5 root palsy occurred in 5 (2 with ACCF and 3 with PLF) cases (1.4 %). In all cases, there were no changes in intra-operative neurophysiologic monitoring; C5 palsy did not occur before post-operative day 2. The authors concluded that patients undergoing cervical decompression remain at risk for C5 root palsy despite use of IOM. They stated that given that all patients experienced delayed onset of C5 palsy, MEP, SSEP, and EMG may not be sensitive enough to assess the risk of developing C5 palsy.

**Intraoperative Screw monitoring (Root monitoring)**

Transpeducular screw fixation of spinal segments is a key element in spinal surgery to achieve maximal stability. Screw malposition should be obviated to avoid neurological complications. There are published methods of applying evoked EMG to control screw position in relation to neural structures. These studies demonstrated that an intact bony pedicle wall acts as an electrical isolator between the screw and spinal nerve root (Bernhardt et. al., 2015).

Triggered electromyography (t-EMG) for pedicle screw placement was introduced to prevent the misplacement of screws. A study review of 13,948 lumbar and 2,070 thoracic screws revealed the most useful application of t-EMG may be as a warning tool for lumbar pedicle screw malpositioning in the presence of positive stimulation at a threshold of ⩽8mA (Lee, et. al., 2015).

**Scoliosis**

In an analysis of prospectively collected intraoperative neurophysiological monitoring data of 354 consecutive patients undergoing corrective surgery for adolescent idiopathic scoliosis (AIS) to establish the efficacy of multimodal neuromonitoring and to evaluate comparative sensitivity and specificity, it was determined that neurogenic motor-evoked potential (NMEP) monitoring appears to be superior to conventional SSEP monitoring for identifying evolving spinal cord injury. Used in conjunction, the sensitivity and specificity of combined neuromonitoring may reach up to 100%. Multimodality monitoring with SSEP + NMEP should be the standard of care (Kundnani, et al., 2010).

**Lumbar**

Cole et. al. (2014) designed a retrospective propensity score-matched analysis on a national database (MarketScan) between 2006 and 2010 to compare rates of neurological deficits after elective single-level spinal procedures with and without intraoperative neuromonitoring. An identified 85,640 patients underwent single-level spinal procedures including anterior cervical disectomy and fusion (ACDF), lumbar fusion, lumbar laminectomy, or lumbar disectomy. Neuromonitoring was identified
with appropriate Current Procedural Terminology (CPT) codes. Cohorts were balanced on baseline comorbidities and procedure characteristics using propensity score matching. Trauma and spinal tumors cases were excluded.

In conclusion, intraoperative neurological monitoring in single-level procedures, neurological complications were not significantly decreased. No difference was observed in ACDFs, lumbar fusions, or lumbar discectomies.

**Spinal Cord Stimulator**

In a retrospective study performed by Scott & Tamkus (2015), A total of 111 patients were monitored for SCS placement. 106/111 patients (95.5%) were monitored for neuroprotection. 43/111 patients (38.8%) were monitored for spinal cord stimulator placement using SSEP collision, EMG activation, or both. EMG activation was able to confirm laterality in 29/31 cases (93.5%) and activated the desired target muscles in 27/31 (87%) cases. SSEP collision was successful in 18/28 cases (64.3%) and achieved greater than 75% abolition of the rostral response in 13/28 cases (46.4%). The location of the stimulator was adjusted based on IONM feedback in 8/43 (18.6%) cases. Positional compromise was identified by continuous SSEP in 4/111 cases (3.6%) while potential spinal cord injury was detected by SSEP change in 2/111 (1.8%) cases. All positional and spinal cord changes resolved intraoperatively following arm repositioning and surgical intervention accordingly. These initial findings indicate that EMG activation and SSEP collision are effective methods for determining the relative position of spinal cord stimulating devices on the spinal cord. Standard neuroprotective monitoring continues to identify and help resolve positional and spinal cord changes during spinal procedures. The higher success rate for EMG activation may be explained by the relative simplicity of the method that provides nearly instantaneous feedback and does not require additional time for an averaged SSEP response to resolve. By choosing EMG muscles that correspond to the area of the patient’s pain, EMG activation can give further assurance to the surgeon that the stimulator placement will be effective for the patient.

**Intracranial**

**Chiari**

Management of Chiari I is controversial, in part because there is no widely used quantitative measurement of decompression. It has been demonstrated that brainstem auditory evoked responses (BAER) and somatosensory evoked potentials (SSEP) have decreased conduction latencies after wide craniectomy. Chen, et. al. (2012) analyzed these parameters in a suboccipital craniectomy/craniotomy procedure. Thirteen consecutive patients underwent suboccipital decompression for treatment of symptomatic Chiari I. Craniectomy was restricted to the inferior aspect of the nuchal line, and in most cases the bone flap was replaced. Neuronal conduction was monitored continuously with median nerve somatosensory evoked potentials (M-SEP), posterior tibial nerve somatosensory evoked potentials (T-SEP), BAER, or a combination. The M-SEP N20, T-SEP P37, and BAER V latencies were recorded at four milestones —
preoperatively, following craniotomy, following durotomy, and following closure. Five males and eight females, with average age of 9 years, were studied. Clinical improvement was noted in all 13 patients. M-SEP N20 latency decreased from a mean of 18.55 at baseline to 17.75 ms after craniotomy (P = 0.01); to 17.06 ms after durotomy (P = 0.01); and to 16.68 ms after closing (P = 0.02). T-SEP P37 latency did not change significantly. BAER V latency decreased from a mean of 6.25 ms at baseline to 6.14 ms after craniotomy (P = 0.04); to 5.98 ms after durotomy (P = 0.01); and to 5.95 ms after closing (P = 0.45). It was concluded that significant improvements in conduction followed both craniectomy and durotomy. Bone replacement did not affect these results.

Cerebrovascular

Brain Tumor Resection

Aggressive resection of intracranial gliomas has a positive impact on patients' prognosis, but is associated with a risk of neurological complications. For preservation of brain functions and avoidance of major postoperative morbidity various methods of intraoperative neurophysiological monitoring have been introduced into clinical practice. Awake craniotomy and intraoperative mapping of language and sensorimotor functions with direct electrical stimulation allow precise identification of the functionally important neuronal structures and have become standard techniques for removal of cerebral neoplasms affecting eloquent cortical areas and subcortical pathways. Overall, contemporary neurophysiology plays a very important role in guidance of brain tumor surgery, in which it helps to maximize the extent of resection and to minimize the risk of permanent neurological morbidity (Chernov, et. al., 2018).

Cavernous Sinus Tumor

In a study to examine the usefulness of IONM of oculomotor and abducens nerves during surgical treatment of cavernous sinus meningiomas, 43 patients diagnosed with cavernous sinus meningiomas were divided according to their topography. Function of the nerves was scored on original clinical and neurophysiological scales. It was concluded that neurophysiological monitoring of ocular motor nerves enables their intraoperative identification during resections of the cavernous sinus meningiomas. Intraoperative monitoring of nerve III is particularly important in the case of tumors with extra- and intracavernous location, and the monitoring of nerve VI in the case of intracavernous tumors. The outcome of the post-resection monitoring has prognostic value with regard to the clinical status of the nerves on long-term follow-up (Wojciech et. al. 2015).

Vascular

Carotid

Research by Balzer & Chirurg (2005) concluded with an increasing number of endovascular procedures, indirect monitoring in carotid surgery will keep its significance. This includes measuring somatic evoked potentials as well as transcranial
duplex sonography, with regard to the increasing importance of plaque morphology and possible neurological consequences. The general recommendation of applying at least one intraoperative control method is necessary in carotid surgery, even if intraluminal shunts are routinely implanted. In addition, quality control of the peripheral vascular system should be sufficiently documented by using one or more methods of examination. So far, in prospective randomized trials, results have not improved by applying intraoperative monitoring methods. Nevertheless, they are indispensable for the careful vascular surgeon and can help to avoid complications and revision with worse prognosis in some cases.

In an article titled, “Intraoperative neuromonitoring in major vascular surgery,” authors V.C. So and C.C.M. Poon (2016) explain the potential benefits of using neuromonitoring in carotid surgery include the following: detection of intraoperative cerebral ischemia caused by hypoperfusion during cross-clamping, guiding the decision on shunt placement or activation of a stroke protocol; provision of real-time feedback to surgeons regarding surgical technique and shunt function by detecting cerebral ischemia and emboli; and detection of postoperative cerebral ischemia or cerebral hyperperfusion syndrome (CHS).

In conclusion, no neuromonitoring modality has been conclusively proved to be superior when used in carotid surgery. Combining different monitors may increase accuracy. Monitoring of SSEP seems to produce less convincing results. Transcranial Doppler has the added advantage of detecting emboli.

Aortic

The potential benefits of using intraoperative neuromonitoring in high-risk aortic surgery include the following: detection of intraoperative cerebral and spinal cord ischemia, which can assist in optimization of perfusion [such as fine-tuning hemodynamic targets for controlled hypertension, providing an indication for cerebrospinal fluid (CSF) drainage etc.]; and real-time feedback to the surgeon regarding surgical technique and need for surgical salvage.

In summary, IONM is useful in detecting spinal cord ischemia during aortic surgery, even though randomized controlled trials are lacking and multiple factors affect their interpretation. Motor evoked potentials have quicker responses than SSEPs, and with lower false-negative rates. Use of IONM as a strategy to manage hemodynamic optimization, to detect spinal cord ischemia, and to guide reimplantation of intercostal arteries is considered to be supported by class IIb evidence (So, V.C. & Poon, C.C.M., 2016).

Coronary Artery Bypass

In a study done by Colak et al. (2015) examining the influence of intraoperative cerebral oximetry monitoring on neurocognitive function after coronary artery bypass surgery the results indicated that patients with prolonged rSO2 desaturation, defined as rSO2 area under the curve (AUC) of more than 150 min% for desaturation below 20% of
baseline or AUC of more than 50 min% for desaturation below 50% absolute value, had an increased risk of cognitive decline. Postoperative cognitive outcome was significantly better in patients with intraoperative cerebral oximetry monitoring. Prolonged rSO2 desaturation is a predictor of cognitive decline and has to be avoided.

**Arteriovenous malformations (AVM)**

During endovascular procedures for the treatment of spinal cord AVMs, a detailed anatomical analysis of the angioarchitecture of the AVM and of the cord blood supply is mandatory. In association, however, neurophysiological monitoring offers a unique opportunity to investigate normal and pathological hemodynamic patterns in the spinal cord. Complexity and variability of spinal cord vascularization most likely account for deterioration in motor function in spite of unchanged SEPs following embolization of spinal cord AVMs.

This method of monitoring and provocative testing cannot replace a careful analysis of the vascular anatomy of the normal spinal cord and the AVM. However, we believe that the combination of anatomical and neurophysiological data provides the safest embolization of spinal cord AVMs (Sala, et. al. 2000).

Zhou et. al. (2017) performed a study to evaluate the effectiveness of intraoperative neuromonitoring (IONM) during intracranial arteriovenous malformation (AVM) surgery. The data was retrospectively analyzed neurologic dysfunction in patients who underwent AVM surgery with (IONM group) and without IONM (non-IONM group). The sensitivity and specificity of short-term neurologic dysfunction were calculated in the IONM group. IONM parameters were obtained in all patients. There was no significant difference in neurologic dysfunction between patients in the IONM and non-IONM groups. It was observed that a trend toward better postoperative neurologic function in patients undergoing IONM surgery, indicating that IONM is beneficial, especially for patients with grade III AVMs. During surgery, the SEP, MEP, and BAEP results, and the combined SEP, MEP, and BAEP results can predict hemiplegia in patients with grade III and IV AVMs. Furthermore, the EMG and VEP findings have good potential in preventing cranial nerve and visual dysfunction. For awake craniotomies, more studies are needed to demonstrate clinical usefulness in preventing neurologic dysfunction.

**Open Heart Surgery EEG**

Stecker et. al. (2001) studied 109 patients undergoing hypothermic circulatory arrest with neurophysiologic monitoring. The purpose of this study was to determine the factors that influence the neurophysiologic changes during cooling before circulatory arrest, in particular the occurrence of electrocerebral silence. The mean nasopharyngeal temperature when periodic complexes appeared in the electroencephalogram after cooling was 29.6°C 6 3°C, electroencephalogram burst-suppression appeared at 24.4°C 6 4°C, and electrocerebral silence appeared at 17.8°C 6 4°C. The N20-P22 complex of the somatosensory evoked response disappeared at 21.4°C 6 4°C, and the somatosensory evoked response N13 wave disappeared at 17.3°C 6 4°C. The temperatures of these various events were not significantly affected by any
patient-specific or surgical variables, although the time to cool to electrocerebral silence was prolonged by high hemoglobin concentrations, low arterial partial pressure of carbon dioxide, and by slow cooling rates. Only 60% of patients demonstrated electrocerebral silence by either a nasopharyngeal temperature of 18°C or a cooling time of 30 minutes. With the high degree of interpatient variability in these neurophysiologic measures, the only absolute predictors of electrocerebral silence were nasopharyngeal temperature below 12.5°C and cooling longer than 50 minutes.

Laryngeal Nerve

Thyroid

A study was done to evaluate the ability of neuromonitoring to predict postoperative outcome in patients undergoing thyroid surgery for different indications. Three hundred twenty-eight patients (502 nerves at risk) were studied prospectively at a single center. Patients were grouped according to surgical risk (benign and malignant disease, reoperation for benign and for malignant disease). If the electrophysiological response was correlated to postoperative vocal cord function, the sensitivity of neuromonitoring was modest (86% in surgery for benign disease) to low (25% in reoperation for malignant disease); the positive predictive value was modest (overall rate 62%) but acceptable (87%) if corrected for technical problems. Specificity and negative predictive values were high (ie, overall >95%). Stimulation thresholds were not augmented in 11 patients, in whom postoperative palsy developed despite normal intraoperative recordings. Similarly, an electrical field response was elicited in 14 of 21 patients with preoperative vocal cord palsy. Electromyographic recordings did not reveal an abnormal amplitude or a decline in nerve conduction velocity. In conclusion, neuromonitoring is useful for identifying the recurrent laryngeal nerve, in particular if the anatomic situation is complicated by prior surgery, large tissue masses, aberrant nerve course. However, neuromonitoring does not reliably predict postoperative outcome (Hermann et. al., 2004).

In a study done by Dralle et al. (2008), recurrent laryngeal nerve palsy rates (RLNPR) varied widely after thyroid surgery, ranging from 0%–7.1% for transient RLN palsy to 0%–11% for permanent RLN palsy. These rates did not differ much from those reported for visual nerve identification without the use of IONM. Six studies with more than 100 nerves at risk (NAR) each evaluated RLNPR by contrasting IONM with visual nerve identification only. Recurrent laryngeal nerve palsy rates tended to be lower with IONM than without it, but this difference was not statistically significant. Six additional studies compared IONM findings with their corresponding postoperative laryngoscopic results. Those studies revealed high negative predictive values (NPV; 92%–100%), but relatively low and variable positive predictive values (PPV; 10%–90%) for IONM, limiting its utility for intraoperative RLN management. Apart from navigating the surgeon through challenging anatomies, IONM may lend itself as a routine adjunct to the gold standard of visual nerve identification.

Hip Replacement/Dysplasia
Nerve injury can occur from major hip surgery. Hesper et. al. (2017) investigated the feasibility and safety of neuromonitoring during hip preservation surgery and the incidence of alerting events during such monitoring. Twenty-five adult patients underwent surgical hip dislocation for femoroacetabular impingement. Upper and lower extremity somatosensory evoked potentials, lower extremity transcranial motor evoked potentials, and lower extremity electromyography were recorded. It was observed that there was a temporary reduction of the monitored parameters in twelve patients (48%) during surgery. There were no clinically significant neurological deficits postoperatively in any cases. It was concluded that while neuromonitoring may be beneficial in complex cases, it is not prudent in every case.

The authors stated that this study had several drawbacks. With a sample size of 25 patients, this rather small study group did not allow for proof of reliability of IONM to predict permanent impairments of nerve function during this particular procedure, as sciatic nerve injury with postoperative deficiency in neuromuscular function has been described in less than 1% of cases after surgical hip dislocation. Furthermore, as alerting events apparently appeared to be dependent on leg positioning while the hip was dislocated, different surgical assistants (who were holding the legs during these cases) might have possibly biased these findings. Because of the need of muscle relaxants for endotracheal intubation, ease of dislocation and surgical exposures, and less tension on muscle structures, intraoperative EMG and TcMEP evaluation done during the usage of muscle relaxants might have been impaired. Until the relaxants wore off, SSEPs were the predominant predictor of nerve injury. However, evaluation of SSEPs were based on calculated averages that were recorded, and thus, transient nerve injury might have sometimes occurred several minutes before notification.

Sierra et. al. (2012) analyzed 1760 patients between 1991 and 2008 within 5 institutions. A major nerve injury was defined as a postoperative motor nerve palsy or sensory deficit present after surgery in the distribution of the femoral or sciatic nerves. Risk factors associated with nerve injury and the treatment and degree of neurologic recovery were reviewed from medical records. Thirty-six of the 1760 patients (2.1%) had a major nerve deficit of the sciatic or femoral nerve develop. We identified no patient or surgical risk factor associated with the occurrence of nerve injury. Seventeen of the 36 patients had complete recovery. The median time to recovery or plateau was 5.5 months (range, 2 days to 24 months). The incidence of sciatic and femoral nerve injury during PAO is less than previously reported.

**Intraoperative Somatosensory Evoked Potentials for Cochlear Implantation**

American Academy of Neurology’s “Principles of Coding for Intraoperative Neurophysiologic Monitoring (IOM) and Testing” did not mention cochlear implantation.

American Speech-Language-Hearing Association (ASHA)’s Technical Report on “Cochlear Implants” did not mention somatosensory evoked potentials (SSEPs) as a management tool.

**Intraoperative Somatosensory Evoked Potentials During Cervical Facet Injections**

An UpToDate review on “Subacute and chronic low back pain: Nonsurgical interventional treatment” (Chou, 2017) does not mention “neuroimaging or intraoperative monitoring” for facet joint injection.
Intraoperative Somatosensory Evoked Potentials During Decompression of the Trigeminal Nerve

An UpToDate review on “Trigeminal neuralgia” (Bajwa et al, 2017) does not mention intraoperative monitoring or intraoperative SSEP monitoring.

Intraoperative Somatosensory Evoked Potentials During Rotator Cuff Repair

An UpToDate review on “Management of rotator cuff tears” (Martin and Martin, 2017) does not mention intraoperative SSEP monitoring.

Intra-Operative Neuromonitoring During Carpal Tunnel Release

An UpToDate review on “Surgery for carpal tunnel syndrome” (Hunter and, Simmons, 2018) does not mention neuromonitoring, neuromuscular junction monitoring, or somatosensory evoked potential monitoring as a management tool

Regulatory Status

Intraoperative Neurophysiologic Monitoring (IONM) is a procedure and therefore not subject to FDA regulation. However, any medical devices, drugs, biologics, or tests used as a part of this procedure may be subject to FDA regulation.

The following list of codes are intended for reference purposes only, is not an all-inclusive code listing, and does not imply that the service is covered or non-covered. Applicable codes include but are not limited to:

<table>
<thead>
<tr>
<th>Intraoperative electromyographic (EMG)</th>
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<tbody>
<tr>
<td>95860</td>
<td>Needle electromyography; 1 extremity with or without related paraspinal areas</td>
</tr>
<tr>
<td>95861</td>
<td>Needle electromyography; 2 extremities with or without related paraspinal areas</td>
</tr>
<tr>
<td>95865</td>
<td>Needle electromyography; larynx</td>
</tr>
</tbody>
</table>

Intraoperative brainstem auditory evoked response (BAER)

| 92585                                 | Auditory evoked potentials for evoked response audiometry and/or testing of the central nervous system; comprehensive |
| 92586                                 | Auditory evoked potentials for evoked response audiometry and/or testing of the central nervous system; limited |

Somatosensory evoked potentials (SEPs, SSEPs)
<table>
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<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
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<td>95925</td>
<td>Short-latency somatosensory evoked potential study, stimulation of any/all peripheral nerves or skin sites, recording from the central nervous system; in upper limbs</td>
</tr>
<tr>
<td>95926</td>
<td>Short-latency somatosensory evoked potential study, stimulation of any/all peripheral nerves or skin sites, recording from the central nervous system; in lower limbs</td>
</tr>
<tr>
<td>95927</td>
<td>Short-latency somatosensory evoked potential study, stimulation of any/all peripheral nerves or skin sites, recording from the central nervous system; in the trunk or head</td>
</tr>
<tr>
<td>95938</td>
<td>Short-latency somatosensory evoked potential study, stimulation of any/all peripheral nerves or skin sites, recording from the central nervous system; in upper and lower limbs</td>
</tr>
</tbody>
</table>

**Intraoperative Monitoring**

<table>
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<tr>
<th>Code</th>
<th>Description</th>
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<td>95940</td>
<td>Continuous intraoperative neurophysiology monitoring in the operating room, one on one monitoring requiring personal attendance, each 15 minutes (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>95941</td>
<td>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 (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>G0453</td>
<td>Continuous intraoperative neurophysiology monitoring, from outside the operating room (remote or nearby), per patient, (attention directed exclusively to one patient) each 15 minutes (list in addition to primary procedure)</td>
</tr>
</tbody>
</table>

**Scientific references**


American Association of Neurological Surgeons/Congress of Neurological Surgeons (AANS/CNS) Spine Section: Neuromonitoring during routine spine surgery


Bajwa ZH, Ho CC, Khan SA. Trigeminal neuralgia. UpToDate Inc., Waltham, MA. Last reviewed June 2017.


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Hunter AA, Simmons BP. Surgery for carpal tunnel syndrome. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed December 2018


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Usefulness of intraoperative monitoring of oculomotor and abducens nerves during surgical treatment of the cavernous sinus meningiomas. Advances in Medical Sciences. 2015: 60 (1). https://doi.org/10.1016/j.advms.2014.08.009.


Policy implementation and updates

Sept 2018: Complete reformatting of content and update of policy guidance including expanded coverage.

October 2019: reformatting, addition to background and policy guidelines

January 2021: no changes to policy coverage