Principles of Coding for Intraoperative Neurophysiologic Monitoring (IOM) and Testing[1]

BACKGROUND

Intraoperative neurophysiologic monitoring (IOM) and testing are medical procedures that have been in standard practice for almost 30 years. The procedures allow monitoring of neurophysiologic signals during a surgical procedure whenever the neuroaxis is at risk as a consequence of either the surgical manipulation or the surgical environment. IOM is an umbrella monitoring term and includes electroencephalography (EEG), cranial nerve evoked potentials (EPs), brain-stem auditory EPs (BAEPs), motor EPs (MEP), somatosensory EPs (SEP), nerve conduction, and electromyography (EMG) signals. Much like the other instrumental clinical monitoring technologies,

such as cardiac or capnic monitoring, randomized controlled trials establishing efficacy of IOM have not been done. Current best data, accumulated over the past two decades, have been derived through comparisons with historical controls and in the number of complications avoided through IOM. Difficulties in procedural blinding would impede accumulation of randomized controlled data. This status is not unlike that of intraoperative transesophageal echocardiography (TEE) or perioperative echocardiography (POE), two other widely-endorsed monitoring technologies (Memtsoudis et. al., 2006, Ng 2009). Both neurophysiologic IOM and TEE/POE are recognized medical practice standards reliant on experience, case series and retrospective analyses.

IOM is of value in surgeries at diverse locations. The types of diseases for which monitoring is helpful also vary. For instance IOM may be necessary for carotid endarterectomies, removal of cortical-hemispheric lesions, extirpation of epileptic foci, brain stem surgeries, spinal corrections and peripheral nerve repairs to name some examples. IOM is used in neurosurgery, orthopedic, vascular, cardiothoracic and other surgical specialties. A compilation of recent reviews for these various areas is available (Nuwer, 2008). This policy addresses only surgical intraoperative monitoring and does not address monitoring performed in radiologic suites. The quality, extent and type of monitoring are dependent on the nature and location of the lesions. The utility of monitoring is exquisitely reliant on the rigors of the monitoring procedure and protocols, and the clinical expertise of the monitoring physician. We list below several

significant instances each of which has independently demonstrated the value of IOM in averting neural injuries during surgery.

[1] Approved by the AAN Board of Directors on February 10, 2012; replaces previous AANPA policy (2010-12).

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 (Redekop & Ferguson, 1992; Cloughesy et al., 1993; Woodworth et al., 2007). 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 (Nuwer et al., 1995). The incidence of false negative cases, wherein an operative complication

occurred without having been detected by the monitoring procedure, was small: 0.06% (Nuwer et al., 1995).

3. Technology Assessment of Monitoring in Spinal Surgeries

A technology assessment by the McGill University Health Center (Erickson et al., 2005) 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 quadriparesis have shown that both SEP and MEP monitoring had predicted adverse outcomes in a timely fashion (Schwartz et al., 2007; Lee et al., 2006; Nuwer

et al., 1995; Jones et al., 2003; Meyer et al., 1988; Pelosi et al., 2002; Hilibrand et al., 2004; Langeloo et al. 2003; Mostegl et al. 1988; Eggspuehler et al 2007; Leung et al. 2005; Khan et al., 2006; Sutter et al., 2007; Weinzieri et al., 2007). 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 pre-operative 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 (MacDonald & Janusz, 2002; Jacobs et al., 2000; Cunningham et al., 1987; Kaplan et al., 1986; Leung et al., 2005). 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. Common Types of Alerting Events Observed During Monitoring

Another recent study (Lee et al., 2006) described types of neurophysiologic alerts and correlated them with postoperative neurological deficits that occurred during the course of 267 procedures involving anterior cervical spine surgery utilizing EMG, transcranial electrical motor and somatosensory evoked potential monitoring. In this study, 18.4 % of cases resulted in at least one intraoperative neurophysiologic alert; and major alerts believed to be related to specific intraoperative surgical maneuvers were identified in 4.6% of the patients monitored. In 88% of the patients with relevant amplitude loss that was thought to be related to the surgical procedure, the signal response returned once appropriate intraoperative corrective measures were taken.

7. Value of EMG Monitoring

Selective posterior rhizotomy in cerebral palsy significantly reduces spasticity, increases range of motion, and improves functional skills (Staudt et al., 1995). 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 (Nuwer, 2008).

8. Futility of Monitoring Inappropriate Pathways

In order to be useful, monitoring should assess the appropriate sensory or motor pathways. Incorrect pathway monitoring could miss detection of neural compromise. Examples of "wrong pathway" monitoring have been shown to have resulted in adverse outcomes (Lesser et al., 1986).

9. 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 the AAN and the American Clinical Neurophysiology Society, 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) (Nuwer et al., 2012). 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).

NEUROPHYSIOLOGIC TECHNIQUES USED IN IOM

Several neurophysiologic testing modalities are useful during IOM. The location and type of surgery determine the chosen testing modality. The tests and codes listed here may be used individually or in combination.

- Electroencephalography (EEG);
  - With direct physician supervision, use codes 95822 plus 95940 and/or 95941
  - With general physician supervision, use code 95955
- Electrocorticography (ECoG);
  - Use code 95829
- Direct cortical stimulation to localize function;
  - Use codes 95961, 95962
- Deep brain stimulation electrode placement
  - Use codes 95961, 95962
- Pallidotomy site testing;
  - Use codes 95961, 95962
- Somatosensory evoked potential (SEP) monitoring
  - Use codes 95925, 95926, 95927, or 95938 plus 95940 and/or 95941

- Intraoperative SEP identification of the sensorimotor cortex
  - Use codes 95961, 95962
- Motor evoked potentials (MEP)
  - Use codes 95928, 95929, or 95939 plus 95940 and/or 95941
- Mapping the descending corticospinal tract
  - Use codes 95928, 95929, or 95939 plus 95940 and/or 95941
- Brainstem auditory evoked potentials
  - Use code 92585 plus 95940 and/or 95941
- Peripheral nerve stimulation and recording
  - Use one code from among codes 95907-95913, plus 95940 and/or 95941
- Oculomotor, facial, trigeminal and lower cranial nerve monitoring
  - Use codes 95867, 95868 and/or 95933 plus 95940 and/or 95941
- EMG monitoring and testing of peripheral limb pathways
  - Use codes 95861, 95862 or 95870 plus 95940 and/or 95941
- Pedicle screw stimulation
  - Use codes 95861, 95862 or 95870 plus 95940 and/or 95941
- Selective dorsal rhizotomy rootlet testing;
  - Use codes 95861, 95862 or 95870 plus 95940 and/or 95941
- Transcranial electrical MEPs (tceMEPs) for external anal and urethral sphincter muscles monitoring.
  - Use code 95870 plus 95940 and/or 95941

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 below.

1. 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.

2. 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, pre-operative planning and continuous communication between the anesthesiologist and the monitoring team is expected.

3. Recording Conditions

It is also expected that a specifically trained technologist or non-physician 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.

4. 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).

5. Communications

Monitoring may be performed from a remote site, as long as a well-trained technologist (see detail above) 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.

6. 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 (OR). Code 95941 supervision require continuous physician monitoring which can be provided online or in the operating room (OR). Codes 95961-95962 (Functional cortical localization with brain stimulation) require personal physician supervision in the OR.

USE OF CODES 95940, 95941 AND THEIR BASE PROCEDURE CODES

1. IOM is a procedure that describes ongoing electrophysiologic testing, and monitoring performed during surgical procedures. It includes only the time spent during an ongoing, concurrent, real-time electrophysiologic monitoring.

2. Time spent in clinical activities, other than those above, should not be billed under 95940 and/or 95941. The time spent performing or interpreting the baseline electrophysiologic studies must not be counted as intraoperative monitoring, but represents separately reportable procedures.

   For example, 95940 and 95941 are distinct from performance of specific types of pre-procedural baseline electrophysiologic studies (95860, 95861, 95867, 95868, 95907-95913. 95933, 95937) or other interpretation of specific types of baseline electrophysiologic studies (95985, 95922, 95925-95930, 95938, 95939).

   The supervising physician time spent in the operating room includes the time from entering until leaving the operating room, except for the time spent interpreting the baseline testing. For remote monitoring, it includes time from initiating to discontinuing monitoring except for the time spent interpreting the baseline testing.

3. Note that the supervision requirements for each underlying test or primary test modality vary, and must be met (Medicare Benefit Policy Manual). For example, cortical mapping during monitoring requires personal supervision.

4. Codes 95940 and 95941 may not be reported by the surgeon or anesthesiologist performing an operative procedure, since it is included in the global package if they serve as the IOM supervising physician.. The surgeon performing an operative procedure may not bill other 90000 series neurophysiology testing codes for intraoperative neurophysiology testing (e.g., 92585, 95822, 95860, 95861, 95867, 95868, 95870, 95907-95913, 95925-95939) since they are also included in the global package (Medicare Benefit Policy Manual). However, when IOM or baseline procedures are performed by a different, monitoring physician during the procedure, it is separately reportable by the monitoring supervising physician.

5. Codes 95940 and 95941 is performed in the hospital setting. Monitoring of a patient with codes 95940 and 95941 should use hospital site of service (site 21), or hospital outpatient surgery center (site 22), even if the monitoring physician is located in an office. When supervising and interpreting IOM on a hospitalized patient, the supervising physician codes uses modifier -26.

6. Code 95940 requires one-on-one monitoring. Simultaneous cases cannot be coded with 95940. Code 94941 allows for reporting simultaneous cases without division of time between them. 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).

CPT/HCPCS CODES

Codes 95940, 95941 describe ongoing neurophysiologic monitoring, testing, and data interpretation distinct from performance of specific type(s) of baseline neurophysiologic study(s) performed during surgical procedures. When the service is performed by the surgeon or anesthesiologist, the professional services are included in the surgeon's or anesthesiologists's primary services code(s) for the procedure and are not reported separately. Do not report these codes for automated monitoring devices that do not require continuous attendance by a professional qualified to interpret the testing and monitoring.

Recording and testing are performed either personally or by a technologist who is physically present with the patient during the service. Supervision is performed either in the operating room or by real time connection outside the operating room. The monitoring professional must be solely dedicated to performing the intraoperative neurophysiologic monitoring

and must be available to intervene at all times during the service as necessary, for the reported time period(s). For any given period of time spent providing these services, the service takes full attention and, therefore, other clinical activities beyond providing and interpreting of monitoring cannot be provided during the same period of time.

Throughout the monitoring, there must be provisions for continuous and immediate communication directly with the operating room team in the surgical suite. One or more simultaneous cases may be reported (95941). When monitoring more than one procedure, there must be the immediate ability to transfer patient monitoring to another monitoring professional during at he surgical procedure should that individual's exclusive attention be required for another procedure. Report 95941 for all remote or non-one-on-one monitoring time connected to each case regardless of overlap with other cases.

Codes 95940, 95941 include only the ongoing neurophysiologic monitoring time distinct from performance of specific type(s) of baseline neurophysiologic study(s), or other services such as intraoperative functional cortical or subcortical mapping. Codes 95940 and 95941 are reported based upon the time spent monitoring only, and not the number of baseline tests performed or parameters monitored. The time spent performing or interpreting the baseline neurophysiologic study(ies) should not be counted as intraoperative monitoring, but represents separately reportable procedures. When reporting 95940 and 95941, the same neurophysiologic study(ies) performed at baseline should be reported not more than once per operative session. Baseline study reporting is based upon the total unique studies performed. For example, if during the course of baseline testing and one-on-one monitoring, two separate nerves have motor testing performed in conjunction with limited single extremity EMG, then 95885 and 95907 would be reported in addition to 95940. For procedures that last beyond midnight, report services using the day on which the monitoring began and using the total time monitored.

Code 95940 is reported per 15 minutes of service. Code 95940 requires reporting only the portion of time the monitoring professional was physically present in the operating room providing one-on-one patient monitoring and no other cases may be monitored at the same time. Report continuous intraoperative neurophysiologic monitoring in the operating room (95940) in addition to the services related to monitoring from outside the operating room (95941).

Code 95941 should be used once per hour even if multiple methods of neurophysiologic monitoring are used during the time. Code 95941 requires the monitoring of neurophysiological data that is collected from the operating room continuously on-line in real time via a secure data link. When reporting 95941, real-time ability must be available through sufficient data bandwidth transfer rates to view and interrogate the neurophysiologic data contemporaneously.

Report 95941 for all cases in which there was no physical presence by the monitoring professional in the operating room during the monitoring time or when monitoring more than one case in an operating room. It is also used to report the time of monitoring physically performed outside of the operating room in those cases where monitoring occurred both within and outside the operating room. Do not report 95941 if the monitoring lasted 30 minutes or less.

Intraoperative neurophysiology monitoring codes 95940 and 95941 are each used to report the total duration of respective time spent providing each services, even if that time is not in a single continuous block.

95940 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)

95941 Continuous intraoperative neurophysiologic 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)

(Use 95940 & 95941 in conjunction with the study performed, 92585, 95822, 95860-95870, 95907-95913, 95925-95939)

(For time spent waiting on standby before monitoring, use 99360) (For electrocorticography, use 95829)

(For intraoperative EEG during nonintracranial surgery, use 95955)

(For intreaoperative functional cortical or subcortical mapping, see 95961- 95962)

(For intraoperative neurostimulator programming and analysis, see 95970- 95979)

CODES FOR PRIMARY PROCEDURES USED AS BASE CODES

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

95822 Electroencephalogram (EEG); recording in coma or sleep only

95860 Needle electromyography; one extremity with or without related paraspinal areas

95861 Needle electromyography; two extremities with or without related paraspinal areas

95867 Needle electromyography; cranial nerve supplied muscle(s), unilateral

95868 Needle electromyography; cranial nerve supplied muscles, bilateral

95870 Needle electromyography; limited study of muscles in one extremity or non-limb (axial) muscles (unilateral or bilateral), other than thoracic paraspinal, cranial nerve supplied muscles, or sphincters

95907 Nerve conduction studies; 1-2 studies

95908 3-4 studies

95909 5-6 studies

95910 7-8 studies

95911 9-10 studies

95912 11-12 studies

95913 13 or more studies

95925 Short-latency somatosensory evoked potential study, stimulation of any/all peripheral nerves or skin sites, recording from the central nervous system; in upper limbs

95926 Short-latency somatosensory evoked potential study, stimulation of any/all peripheral nerves or skin sites, recording from the central nervous system; in lower limbs

95927 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

95928 Central motor evoked potential study (transcranial motor stimulation); upper limbs

95929 Central motor evoked potential study (transcranial motor stimulation); lower limbs

95930 Visual evoked potential

95933 Orbicularis oculi (blink) reflex, by electrodiagnostic testing

95937 Neuromuscular junction testing (repetitive stimulation, paired stimuli), each nerve, any one method

95938 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

95939 Central motor evoked potential study (transcranial motor stimulation); in upper and lower limbs

USE OF OTHER PROCEDURE CODES FOR INTRAOPERATIVE MONITORING AND/OR TESTING

Implanted Device Neurophysiology Codes

Codes for use with implanted devices (95961, 96962, 95970-95979) Two series of codes are used to locate the proper sites for deep brain or spinal cord implanted devices and to test the device's integrity.

Codes 96961 (first hour) and 96962 (additional hours) are used for intraoperative testing of electrode placement. Code 95970 is used to check a device's integrity. Rarely, the devices are also programmed while in the operating room, and when done those services are coded using 95971 through 95979. These codes are:

95970 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, configuration of wave form, battery status, electrode selectability, output modulation, cycling, impedance and patient compliance measurements); simple or complex brain, spinal cord, or peripheral (ie, cranial nerve, peripheral nerve, autonomic nerve, neuromuscular) neurostimulator pulse generator/ transmitter, without reprogramming

95971 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, configuration of wave form, battery status, electrode selectability, output

modulation, cycling, impedance and patient compliance measurements); simple spinal cord, or peripheral (ie, peripheral nerve, autonomic nerve, neuromuscular) neurostimulator pulse generator/ transmitter, with intraoperative or subsequent programming

95972 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, configuration of wave form, battery status, electrode selectability, output modulation, cycling, impedance and patient compliance measurements); complex spinal cord, or peripheral (except cranial nerve) neurostimulator pulse generator/transmitter, with intraoperative or subsequent programming, first hour

95973 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, configuration of wave form, battery status, electrode selectability, output modulation, cycling, impedance and patient compliance measurements); complex spinal cord, or peripheral (except cranial nerve) neurostimulator pulse generator/transmitter, with intraoperative or subsequent programming, each additional 30 minutes after first hour (List separately in addition to code for primary procedure)

95974 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, configuration of wave form, battery status, electrode selectability, output modulation, cycling, impedance and patient compliance measurements); complex cranial nerve neurostimulator pulse generator/transmitter, with intraoperative or subsequent programming, with or without nerve interface testing, fi hour

95975 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, configuration of wave form, battery status, electrode selectability, output modulation, cycling, impedance and patient compliance measurements); complex cranial nerve neurostimulator pulse generator/transmitter, with intraoperative or subsequent programming, each additional 30 minutes after first hour (List separately in addition to code for primary procedure)

95978 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, battery status, electrode selectability and polarity, impedance and patient compliance measurements), complex deep brain neurostimulator pulse generator/ transmitter, with initial or subsequent programming; first hour

95979 Electronic analysis of implanted neurostimulator pulse generator system (eg, rate, pulse amplitude and duration, battery status, electrode selectability and polarity, impedance and patient compliance measurements), complex deep brain neurostimulator pulse generator/ transmitter, with initial or subsequent programming; each additional 30 minutes after first hour (List separately in addition to code for primary procedure)

Functional Cortical Mapping Codes

95829 Electrocorticogram at surgery (separate procedure)

95961 Functional cortical and subcortical mapping by stimulation and/ or recording of electrodes on brain surface, or of depth electrodes, to provoke seizures or identify vital brain structures; initial hour of physician attendance

95962 Functional cortical and subcortical mapping by stimulation and/ or recording of electrodes on brain surface, or of depth electrodes, to provoke seizures or identify vital brain structures; each additional hour of physician attendance (List separately in addition to code for primary procedure)

Three codes are used in the operating room to locate abnormal regions or regions that serve key brain functions. This includes the electrocorticography (ECoG) code 95829, which is used to record EEG directly from the exposed brain. This is used to find areas of cortex that are damaged or that may be the source of epileptic seizures. This also includes the functional cortical stimulation codes 95961 (first hour) and 95962 (additional hours). Most often those codes are used when the brain is stimulated electrically and the results are monitored behaviorally in a patient who is awake during neurosurgery. These guide the surgeon as to which portions of the exposed brain could or should be removed or which should be preserved.

APPENDIX A – DIAGNOSES THAT SUPPORT MEDICAL NECESSITY

Note: All ICD-9-CM codes listed below may be viewed as medically necessary; however, there may be other diagnostic codes not included in this list that are deserving of consideration for coverage. Such instances may require individual consideration.

015	Spinal tuberculosis
170	Malignant temporal bone
170.2	Malignant neoplasm of vertebral column excluding sacrum and coccyx
191.9	Malignant neoplasm of brain unspecified site
192.0	Malignant neoplasm of cranial nerves
192.1	Malignant neoplasm of cerebral meninges
192.2	Malignant neoplasm of Spinal cord
192.3	Malignant neoplasm of Spinal meninges
192.8	Malignant neoplasm of other specified sites of nervous system
192.9	Malignant neoplasm of nervous system part unspecified
198.3	Secondary malignant neoplasm of brain and Spinal cord
198.4	Secondary malignant neoplasm of other parts of nervous system
198.5	Metastatic disease to thoracic, lumbar and cervical spinal column
213	Temporal bone lesion
213.2	Benign neoplasm of vertebral column excluding sacrum and coccyx
225.0	Benign neoplasm of brain
225.1	Benign neoplasm of cranial nerves
225.2	Benign neoplasm of cerebral meninges
225.2	Meningioma
225.3	Benign neoplasm of Spinal cord
225.4	Benign neoplasm of Spinal meninges
225.8	Benign neoplasm of other specified sites of nervous system
225.9	Benign neoplasm of nervous system part unspecified
228.02	Intracranial hemangioma
237.0	Neoplasm of uncertain behavior of pituitary gland and craniopharyngeal duct
237.1	Neoplasm of uncertain behavior of pineal gland
237.3	Glomus tumor
237.5	Neoplasm of uncertain behavior of brain and Spinal cord
237.6	Neoplasm of uncertain behavior of meninges
237.70	Neurofibromatosis unspecified
237.71	Neurofibromatosis type 1 von recklinghausen's disease
237.72	Neurofibromatosis, type 2 (acoustic neurofibromatosis)
237.9	Neoplasm of uncertain behavior of other and unspecified parts of nervous system
239.6	Neoplasm of unspecified nature of brain
324.0	Intracranial abscess
324.1	Intraspinal abscess
324.1	Intraspinal abscess
324.9	Intracranial and intraspinal abscess of unspecified site
336.0	Syringomyelia and syringobulbia
336.1	Vascular myelopathies
336.2	Syrinx and other spinal cord diseases
336.3	Myelopathy in neoplastic disease
336.8	Other myelopathy
336.9	Unspecified disease of spinal cord. Cord compression NOS. Myelopathy NOS
343.8	Other specified infantile cerebral palsy
343.9	Infantile cerebral palsy unspecified
345.5	Localization-related (focal) (partial) epilepsy and epileptic syndromes with simple partial seizures
348.4	Compression of brain
349.81	Cerebrospinal fluid rhinorrhea
350.1	Trigeminal neuralgia
350.2	Atypical face pain
351.8	Hemifacial spasm

352.9 Unspecified disorder of cranial nerves

353.0 Brachial plexus lesions

353.1 Lumbosacral plexus lesions

353.2 Cervical root lesions not elsewhere classified

353.3 Thoracic root lesions not elsewhere classified

353.4 Lumbosacral root lesions not elsewhere classified

383 Acute mastoiditis

383.01 Mastoiditis w/subperiosteal abscess

383.32 Post mastoidectomy cholesteatoma

385.3 Cholesteatoma of middle ear and mastoid

385.30 Cholesteatoma, unspecified

385.33 Cholesteatoma of middle ear and mastoid

386.01 Cochleovestibular

386.02 Cochlear

386.03 Vestibular

388.61 Cerebrospinal fluid otorrhea

430 Subarachnoid hemorrhage

431 Intracerebral hemorrhage

432.0 Nontraumatic extradural hemorrhage

432.1 Subdural hemorrhage

432.9 Unspecified intracranial hemorrhage

433.00 Occlusion and stenosis of basilar artery without cerebral infarction

433.01 Occlusion and stenosis of basilar artery with cerebral infarction

433.10 Occlusion and stenosis of carotid artery without cerebral infarction

433.11 Occlusion and stenosis of carotid artery with cerebral infarction

433.20 Occlusion and stenosis of vertebral artery without cerebral infarction

433.21 Occlusion and stenosis of vertebral artery with cerebral infarction

433.30 Occlusion and stenosis of multiple and bilateral precerebral arteries without cerebral infarction

433.31 Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction

433.80 Occlusion and stenosis of other specified precerebral artery without cerebral infarction

433.81 Occlusion and stenosis of other specified precerebral artery with cerebral infarction

433.90 Occlusion and stenosis of unspecified precerebral artery without cerebral infarction

433.91 Occlusion and stenosis of unspecified precerebral artery with cerebral infarction

434.0 Cerebral thrombosis

434.01 Cerebral thrombosis with cerebral infarction

434.1 Cerebral embolism

434.11 Cerebral embolism with cerebral infarction

434.9 Cerebral artery occlusion, unspecified

434.90 Cerebral artery occlusion, unspecified without cerebral infarction

434.91 Cerebral artery occlusion, unspecified with cerebral infarction

435.0 Basilar artery syndrome

435.1 Vertebral artery syndrome

435.2 Subclavian steal syndrome

435.3 Vertebrobasilar artery syndrome

435.6 Other specified transient cerebral ischemias

435.8 Other specified transient cerebral ischemias

435.9 Unspecified transient cerebral ischemia

437.3 Cerebral aneurysm nonruptured

437.5 Moyamoya disease

441.00 Dissection of aorta aneurysm unspecified site

441.01 Dissection of aorta thoracic

441.02 Dissection of aorta abdominal

441.03 Dissection of aorta thoracoabdominal

441.1 Thoracic aneurysm ruptured

441.2 Thoracic aneurysm without rupture

441.3 Abdominal aneurysm ruptured

441.4 Abdominal aneurysm without rupture

441.5 Aortic aneurysm of unspecified site ruptured

441.6 Thoracoabdominal aneurysm ruptured

441.7 Thoracoabdominal aneurysm without rupture

441.9 Aortic aneurysm of unspecified site without rupture

443.2	Other arterial Dissection
443.21	Dissection of carotid artery
443.24	Dissection of vertebral artery
443.29	Dissection of other artery
586.43	Semicircular canal fistula
721.0	Spondylosis with or without myelopathy
721.1	Cervical spondylosis with myelopathy
721.2	Spondylosis with or without myelopathy
721.41	Spondylosis with myelopathy thoracic region
721.42	Spondylosis with myelopathy lumbar region
721.7	Spondylosis with or without myelopathy
721.9	Spondylosis with or without myelopathy
721.91	Spondylosis of unspecified site with myelopathy
722	Displacement of cervical intervertebral disc without myelopathy
722.51	Thoracic or thoracolumbar intervertebral disc
722.6	Degenerative disc disorders without myelopathy
722.70	Intervertebral disc disorder with myelopathy unspecified region
722.71	Intervertebral disc disorder with myelopathy cervical region
722.72	Intervertebral disc disorder with myelopathy thoracic region
722.73	Intervertebral disc disorder with myelopathy lumbar region
722.90	Disc, intervertebral, cervical, cervicothoracic; thoracic, thoracolumbar; lumbar, lumbosacral
722.91	Disc, intervertebral, cervical, cervicothoracic; thoracic, thoracolumbar; lumbar, lumbosacral
722.92	Disc, intervertebral, cervical, cervicothoracic; thoracic, thoracolumbar; lumbar, lumbosacral
722.93	Disc, intervertebral, cervical, cervicothoracic; thoracic, thoracolumbar; lumbar, lumbosacral
723	Spinal stenosis in cervical region
724.00	Spinal stenosis without myelopathy
724.01	Spinal stenosis without myelopathy, thoracic region
724.02	Spinal stenosis without myelopathy, lumbar region, without neurogenic claudication
724.09	Spinal stenosis - other
730	Vertebral oteomyelitis
733.13	Pathologic fracture of vertebrae. Collapse of vertebra NOS
737.10	Kyphosis (acquired) (postural)
737.11	Kyphosis due to radiation
737.12	Kyphosis postlaminectomy
737.19	Other kyphosis acquired
737.20	Lordosis (acquired) (postural)
737.22	Other postsurgical lordosis
737.30	Scoliosis (and kyphoscoliosis) idiopathic
737.31	Resolving infantile idiopathic scoliosis
737.32	Progressive infantile idiopathic scoliosis
737.33	Scoliosis due to radiation
737.34	Thoracogenic scoliosis
737.39	Other kyphoscoliosis and scoliosis
737.40	Unspecified curvature of spine associated with other conditions
737.41	Kyphosis associated with other conditions
737.42	Lordosis associated with other conditions
737.43	Scoliosis associated with other conditions
737.8	Other curvatures of spine associated with other conditions
738.4	Curvature of spine associated with other conditions
738.4	Curvature of spine associated with other conditions
738.43	Spondylolisthesis
741.00	Spina bifida unspecified region with hydrocephalus
741	Spina bifida and Chiari II
741.01	Spina bifida cervical region with hydrocephalus
741.02	Spina bifida dorsal (thoracic) region with hydrocephalus
741.03	Spina bifida lumbar region with hydrocephalus
741.90	Spina bifida unspecified region without hydrocephalus
741.91	Spina bifida cervical region without hydrocephalus
741.92	Spina bifida dorsal (thoracic) region without hydrocephalus

741.93	Spina bifida lumbar region without hydrocephalus
742	Other congenital anomalies of nervous system - used for tethered cord
742.0	Encephalocele
747.81	Anomalies of cerebrovascular system
747.82	Spinal vessel anomaly
756.12	Spondylolisthesis congenital
767.4	Injury to spine and Spinal cord
767.5	Facial nerve injury
767.6	Injury to brachial plexus
767.7	Other cranial and peripheral nerve injuries
781	Hemifacial spasm
801	Temporal bone fracture
805.0	Cervical, closed fracture of vertebral column without mention of spinal cord injury
805.1	Open fracture of cervical vertebra
805.2	Closed fracture of dorsal (thoracic) vertebra without spinal cord injury
805.3	Open fracture of dorsal (thoracic) vertebra without spinal cord injury
805.4	Closed fracture of Lumbar vertebra without spinal cord injury
805.5	Open fracture of Lumbar vertebra without spinal cord injury
805.8	Closed fracture of unspecified vertebra without spinal cord injury
805.9	Open fracture of unspecified vertebra without spinal cord injury
806.01	Closed fracture of c1-c4 level with complete lesion of cord
806.02	Closed fracture of c1-c4 level with anterior cord syndrome
806.03	Closed fracture of c1-c4 level with central cord syndrome
806.04	Closed fracture of c1-c4 level with other specified spinal cord injury
806.05	Closed fracture of c5-c7 level with unspecified spinal cord injury
806.06	Closed fracture of c5-c7 level with complete lesion of cord
806.07	Closed fracture of c5-c7 level with anterior cord syndrome
806.08	Closed fracture of c5-c7 level with central cord syndrome
806.09	Closed fracture of c5-c7 level with other specified spinal cord injury
806.10	Open fracture of c1-c4 level with unspecified spinal cord injury
806.11	Open fracture of c1-c4 level with complete lesion of cord
806.12	Open fracture of c1-c4 level with anterior cord syndrome
806.13	Open fracture of c1-c4 level with central cord syndrome
806.14	Open fracture of c1-c4 level with other specified spinal cord injury
806.15	Open fracture of c5-c7 level with unspecified spinal cord injury
806.16	Open fracture of c5-c7 level with complete lesion of cord
806.17	Open fracture of c5-c7 level with anterior cord syndrome
806.18	Open fracture of c5-c7 level with central cord syndrome
806.19	Open fracture of c5-c7 level with other specified spinal cord injury
806.20	Closed fracture of T1-T6 level with unspecified spinal cord injury
806.21	Closed fracture of T1-T6 level with complete lesion of cord
806.22	Closed fracture of T1-T6 level with anterior cord syndrome
806.23	Closed fracture of T1-T6 level with central cord syndrome
806.24	Closed fracture of T7-T12 level with other specified spinal cord injury
806.25	Closed fracture of T7-T12 level with unspecified spinal cord injury
806.26	Closed fracture of T7-T12 level with complete lesion of cord
806.27	Closed fracture of T7-T12 level with anterior cord syndrome

806.28 Closed fracture of T7-T12 level with central cord syndrome

806.29 Closed fracture of T7-T12 level with other specified spinal cord injury

806.30 Open fracture of T1-T6 level with unspecified spinal cord injury

806.31 Open fracture of T1-T6 level with complete lesion of cord

806.32 Open fracture of T1-T6 level with anterior cord syndrome

806.33 Open fracture of T1-T6 level with central cord syndrome

806.34 Open fracture of T7-T12 level with other specified spinal cord injury

806.35 Open fracture of T7-T12 level with unspecified spinal cord injury

806.36 Open fracture of T7-T12 level with complete lesion of cord

806.37 Open fracture of T7-T12 level with anterior cord syndrome

806.38 Open fracture of T7-T12 level with central cord syndrome

806.39 Open fracture of T7-T12 level with other specified spinal cord injury

806.4 Closed fracture of lumbar spine with spinal cord injury

806.5 Open fracture of lumbar spine with spinal cord injury

806.70 Open fracture of sacrum and coccyx with unspecified spinal cord injury

806.71 Open fracture of sacrum and coccyx with complete cauda equina lesion

806.72 Open fracture of sacrum and coccyx with other cauda equina injury

806.79 Open fracture of sacrum and coccyx with other spinal cord injury

806.8 Closed fracture of unspecified vertebra with spinal cord injury

806.9 Open fracture of unspecified vertebra with spinal cord injury

839.4 Vertebral subluxation

850.4 Concussion with prolonged less of consciousness without return to pre-existing conscious level

951 Injury to cranial nerves

952 Spinal cord injury without bone injury

953.0 Cervical root

953.1 Dorsal root

953.2 Lumbar root

953.3 Sacral root

953.4 Brachial plexus

953.5 Lumbosacral plexus

953.8 Multiple sites

953.9 Unspecified site

955.0 Axillary nerve

955.1 Median nerve

955.2 Ulnar nerve

955.3 Radial nerve

955.4 Musculocutaneous nerve

955.5 Cutaneous sensory nerve, upper limb

955.6 Digital nerve

955.7 Other specified nerve(s) of shoulder girdle and upper limb

955.8 Multiple nerves of shoulder girdle and upper limb

955.9 Unspecified nerve of shoulder girdle and upper limb

956.0 Sciatic nerve

956.1 Femoral nerve

956.2 Posterior tibial nerve

956.3 Peroneal nerve

956.4 Cutaneous sensory nerve, lower limb

956.5 Other specified nerve(s) of pelvic girdle and lower limb

956.6 Multiple nerves of pelvic girdle and lower limb

956.8 Multiple nerves of pelvic girdle and lower limb

956.9 Unspecified nerve of pelvic girdle and lower limb

957.1 Facial palsy/trauma

The following overall criteria must be met:

1. Diagnosis must at least reflect a reason (or need) for surgery
2. Diagnosis should imply a monitorable structure is at risk
3. Current practice includes monitoring the at risk structure
4. There is peer reviewed published literature describing the monitoring of the at risk structure
5. A reasonable monitorist would not question why the surgeon wanted the monitoring

When cranial and/or facial nerves are involved or at risk:

142	Malignant neoplasm of major salivary gland
142.0	Malignant neoplasm of major salivary gland – parotid gland
193	Malignant neoplasm of thyroid gland
210.2	Benign neoplasm of major salivary gland
216.2	Ear and external auditory canal neoplasms
235	Parotid gland
240.9	Simple and unspecified goiter
242	Toxic diffuse goiter
242.2	Thyrotoxicosis with or without goiter
242.3	Toxic nodular goiter (unspecified)
383.22	Petrositis, chronic
385.31	Cholesteatoma of attic
385.32	Cholesteatoma of middle ear
385.35	Diffuse cholesteastosis of middle ear and mastoid
388.11	Blast injury, otic
784.2	Head and neck mass

When in conjunction with superior canal dehiscence and/or when pulsatile tinnitus is a symptom:

386.51	Hyperactive labyrinthine dysfunction, unilateral
386.52	Hyperactive labyrinthine dysfunction, bilateral
386.53	Hypoactive labyrinthine dysfunction, unilateral
386.54	Hypoactive labyrinthine dysfunction, bilateral

When root and/or cord are felt to be at risk and/or pedicular screw thresholding is warranted:

721	Spondylosis and allied disorders
721.3	Lumbosacral spondylosis without myelopathy
722.0	Intervertebral disc disorders without myelopathy
722.1	Lumbar intervertebral disc without myelopathy
722.2	Intervertebral disc disorders without myelopathy
722.4	Degeneration of cervical intervertebral disc
722.52	Lumbar or lumbosacral intervertebral disc
722.80	Postlaminectomy syndrome
722.81	Postlaminectomy syndrome
722.82	Postlaminectomy syndrome
722.83	Postlaminectomy syndrome

When in conjunction with superior canal dehiscence and when indicates significant carotid stenosis:

388.32	Objective or pulsatile tinnitus

APPLICABLE SOCIAL SECURITY AND MEDICARE REGULATIONS

1. Social Security Act (Title XVIII) Standard References, Sections:
   - Title XVIII of the Social Security Act, Section 1862(a)(1)(A). This section allows coverage and payment for only those services that are considered to be medically reasonable and necessary.
   - Title XVIII of the Social Security Act, Section 1833(e). This section prohibits Medicare payment for any claim which lacks the necessary information to process the claim. (Individual sections are available at http://www.cms.hhs.gov/)
2. Medicare Benefit Policy Manual – and Medicare National Coverage Determinations Manual
   - (1). Pub. 100-08 Medicare Program Integrity.
   - 5.1 – Reasonable and Necessary Provisions in LCDs *http://www.cms.hhs.gov/transmittals/Downloads/R63PI.pdf*
   - (2). CHAP 4.doc Version 13.3 NATIONAL CORRECT CODING INITIATIVE POLICY MANUAL *http://www.cms.hhs.gov/NationalCorrectCodInitEd/Downloads/manual.zip*
3. Medicare Benefit Policy Manual Chapter 15 – Covered Medical and Other Health Services, 80 80 - Requirements for Diagnostic X-Ray, Diagnostic Laboratory, and Other Diagnostic Tests.
   - Section 410.32(b) of the Code of Federal Regulations (CFR) requires that diagnostic tests covered under §1861(s)(3) of the Act and payable under the physician fee schedule, with certain exceptions listed in the regulation, have to be performed under the supervision of an individual meeting the definition of a physician (§1861(r) of the Act) to be considered reasonable and necessary and, therefore, covered under Medicare.
   - Of the three levels of supervision, General, Direct and Personal, the add-on code 95940 and 95941 requires that this "Procedure may be performed by a technician with on-line real-time contact with physician." (Medicare Benefit Policy Manual Chapter 15 – Covered Medical and Other Health Services, 80 80 - Requirements for Diagnostic X-Ray, Diagnostic Laboratory, and Other Diagnostic Tests., *http://www.cms.hhs.gov/* manuals/Downloads/bp102c15.pdf *http://www.access.gpo.gov/nara/cfr*

POLICY HISTORY

Approved February 2010, by the AANPA Board of Directors (AAN Policy 2010-12) Amended on February 10, 2012, by the AAN Board of Directors

This policy is updated annually to reflect changes in procedure codes.

SOURCES OF INFORMATION AND BASIS FOR DECISION

American Academy of Neurology. Survey of Members. 2010. (Unpublished)

Cloughesy TF, Nuwer MR, Hoch D, Vinuela F, Duckwiler, G, & Martin, N. Monitoring carotid test occlusions with continuous EEG and clinical examination. Journal of Clinical Neurophysiology 1993; 10(3):363-369.

Cunningham JN Jr., Laschinger JC, Spencer FC. Monitoring of somatosensory evoked potentials during surgical procedures on the thoracoabdominal aorta. J Thorac Cardiovasc Surg 1987; 94:275–285.

Eggspuehler A, Martin A. Sutter, Dieter Grob, Dezsö Jeszenszky, François Porchet and Jiri Dvorak. Multimodal intraoperative monitoring (MIOM) during cervical spine surgical procedures in 246 patients European Spine Journal Volume 16, Supplement 2 / November, 2007.

Erickson L, Costa V, McGregor M. Use of intraoperative neurophysiciological monitoring during spinal surgery. Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC). 2005; Available: www.mcgill. ca/tau. Last accessed Dec 19, 2007.

Huang, BR, Chang, CN, Hsu, JC. Intraoperative electrophysiological monitoring in microvascular decompression for hemifacial spasm Journal of Clinical Neuroscience 16 (2009) 209-213.

Hyun, SJ, Rhim, SC, Kang, JK, Hong, SH, Park, BRG. Combined motor- and somatosensory-evoked potential monitoring for spine and spinal cord surgery: correlation of clinical and neurophysiological data in 85 consecutive procedures Spinal Cord (2009) 47, 616-622.

Jacobs MJ, Elenbass TW, Schurink GWH, Mess WH, Mochtar B. Assessment of spinal cord integrity during thoracoabdominal aortic aneurysm repair. Ann Thorac Surg 2000;74:S1864-1866.

Jones SJ, Buonamassa S, Crockard HA. Two cases of quadriparesis following anterior cervical discectomy, with normal perioperative somatosensory evoked potentials. J Neurol Neurosurgery Psychiatry. 2003 Feb;74(2):273-6.

Kaplan BJ, Friedman WA, Alexander JA, Hampson SR. Somatosensory evoked potential monitoring of spinal cord ischemia during aortic operations. Neurosurg 1986;19:82–90.

Khan MH, Smith PN, Balzer JR, Crammond D, Welch WC, Gerszten P, Scabassi RJ, Kang JD Donaldson WF. Intraoperative somatosensory evoked potential monitoring during cervical spine corpectomy surgery: Experience with 508 cases. Spine 2006; 31(4):E105-E113.

Lee, JY, Hilibrand, AS, Lim, MR, Zavatsky, J, Seiller, S, Schwartz, DM, Vaccaro, AR, Anderson, DG, Albert, TJ. Characterization of neurophysiologic alerts during anterior cervical spine surgery. Spine 2006; 31(17):1916-22.

Lesser, RP, Raudzens, P, Luders, H, Nuwer, MR, Goldie, WD, Morris III, HH, Dinner, DS, Klem, G, Hahn, JF, Shetter, AG, Ginsburg, HH, Gurd, AR. Postoperative neurological deficits may occur despite unchanged intraoperative somatosensory evoked potentials. Annals of Neurology, 1986; 19, 22-25.

Leung YL, Grevitt M, Henderson L, Smith J, Cord monitoring changes and segmental vessel ligation in the "at risk" cord during anterior spinal deformity surgery. Spine 2005; 30 (16): 1870-1874.

MacDonald DB, Janusz M. An approach to intraoperative neurophysiologic monitoring of thoracoabdominal aneurysm surgery. J Clin Neurophysiol 2002;19:43-54.

Mostegl A, Bauer R, Eichenauer M. Intraoperative somatosensory potential monitoring. A clinical analysis of 127 surgical procedures. Spine 1988;13:396–400.

Memtsoudis SG, Rosenberger P, Loffler M, et al The usefulness of transesophageal echocardiography during intraoperative cardiac arrest in noncardiac surgery.Anesth Analg. 2006 Jun;102(6):1653-7.

Meyer PR Jr, Colter HB, Gireesan GT. Operative neurological complications resulting from thoracic and lumbar spine internal fi tion. Clin Orthop Rel Res 1988;237:125–131.

Midori Amano, Michihiro Kohno, Osamu Nagata, Makoto Taniguchi, Shigeo Sora, Hiroaki Sato Intraoperative continuous monitoring of evoked facial nerve electromyograms in acoustic neuroma surgery. Acta Neurochir (2011) 153:1059-1067.

Ng A, Swanevelder J. Perioperative echocardiography for non-cardiac surgery: what is its role in routine haemodynamic monitoring? Br J Anaesth. 2009 Jun;102(6):731-4.

Nuwer, MR (Ed.). Intraoperative monitoring of neural function. Elsevier, Amsterdam, 2008.

Nuwer MR, 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;78:585–589.

Nuwer, M.R., Dawson, E.G., Carlson, L.G., Kanim, L.E.A., Sherman, J.E. Somatosensory evoked potential spinal cord monitoring reduces neurologic deficits after scoliosis surgery: Results of a large multicenter survey.

Electroencephalography and Clinical Neurophysiology 1995; 96:6-11.

Pelosi L, Lamb J, Grevitt M, Mehdian SMH, Webb JK, Blumhardt LD. Combined monitoring of motor and somatosensory evoded potentials in orthopaedic spinal surgery. Clin Neurophysiol 2002;113:1082-1091.

Redekop G, Ferguson G. Correlation of contralateral stenosis and intraoperative electroencephalogram change with risk of stroke during carotid endarterectomy. Neurosurgery. 1992;30:191-4.

Schwartz, DM, Auerback, JD, Dormans, JP, Drummond, J, Bowe, A, Laufer, S, Shah, SA, Bowen, JR, Pizzutillo, PD, Jones, KJ, Drummond, DS. Neurophysiological detection of impending spinal cord injury during scoliosis surgery. J Bone Joint Surg Am. 2007; 89:2440-9.

Staudt, LA, Nuwer, MR, Peacock, WJ. Intraoperative monitoring during selective posterior rhizotomy: technique and patient outcome. Electroencephalography and clinical Neurophysiology 1995;97:296-309.

Sutter M Eggspuehler A, Grob D, Jeszenszky D, Benini A, Porchet F, Mueller A, Dvorak J. The validity of multimodal intraoperative monitoring (MIOM) in surgery of 109 spine and spinal cord tumors. European Spine Journal Volume 16, (2): November, 2007.

Weinzieri MR, Reinacher P, Gilsbach JM, Rohde V. Combined motor and somatosensory evoked potentials for Intraoperative monitoring: intra- and postoperative data in a series of 69 operations. Neurosurgery Rev (2007) 30(2):109-116.

Woodworth GF, McGirt MJ, Than KD, Huang J, Perler BA, Tamargo RJ. Selective versus routine intraoperative shunting during carotid endarterectomy: a multivariate outcome analysis. Neurosurgery. 2007;61:1170-6.