White Paper: The Use of Intraoperative Monitoring to Prevent Complications During Spinal Surgery

For Hospital Groups, ASCs, and Specialty Medical Facilities

Executive Summary

Spinal surgery involves numerous procedures that place the spinal cord, nerve roots, and key blood vessels at high risk for injury. Intraoperative monitoring (IOM) provides an opportunity to assess the functional integrity of susceptible neural elements during surgery by detecting electrical signals produced by the nervous system in response to sensory or electrical stimuli. Various procedures are used to monitor the integrity of neural pathways during high-risk, neurosurgical, orthopedic, and vascular surgeries.

The principal goal of IOM is to identify nervous system impairment in the hope that prompt intervention will prevent permanent deficits. Correctable factors at surgery include circulatory disturbance, excess compression from retraction, bony structures, hematomas, and mechanical stretching.

Common Spinal Surgeries and Potential Complications

When conservative management is attempted and fails, surgery may be indicated for persistent back pain that involves an anatomical problem, e.g., a herniated disc, spinal stenosis, or spondylolisthesis. See the table below for a summary of common spinal surgical procedures, and the potential complications associated with each procedure.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Description</th>
<th>Potential Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discectomy</td>
<td>The surgical removal of herniated disc material that presses on a nerve root or the spinal cord</td>
<td>Damage to the disc operated on, spinal fluid leaks, bleeding, infection</td>
</tr>
<tr>
<td>Laminectomy (spinal decompression)</td>
<td>An open surgical procedure that involves removing a small portion of the bone in the spine, called the lamina, in order to alleviate pressure on spinal nerves; fragments of a ruptured disc may also be removed during surgery</td>
<td>Nerve root damage, bowel/bladder incontinence, cerebrospinal fluid leak, infection, post-operative instability of the operated level</td>
</tr>
<tr>
<td>Spinal fusion</td>
<td>A procedure that joins two bones (vertebrae) in the spinal column together to eliminate pain caused by movement</td>
<td>Infection, urinary problems, pseudoarthrosis (bone graft site causes pain and can lead to a fusion that does not heal), adjacent segment disease requiring re-fusion, blood clots</td>
</tr>
<tr>
<td>Artificial disc replacement</td>
<td>A relatively new procedure that is an alternative to spinal fusion when the cause of injury is a degenerated disc; an artificial disc is used to replace the damaged disc</td>
<td>Death, major bleedings, severe nerve injury</td>
</tr>
</tbody>
</table>

With spinal fusion, one of the most significant risks occurs when the spinal discs either above or below the fusion wear out and become extremely painful. The incidence of this complication, which is known as adjacent segment disease (ASD) and requires re-fusion of the spine to include the newly affected areas, can be as high as 40%.
Although artificial disc replacement is approved by the U.S. Food and Drug Administration (FDA) for single-level disc replacement (lumbar), it may be appropriate for only a very limited group of patients. Post-procedure review for 5 to 7 years is mandatory for patients who undergo the procedure, and patients with multiple degenerating discs or who have had multiple failed back surgeries may not be candidates for artificial disc replacement.

**Common IOM Techniques Used During Spinal Procedures**

**Intraoperative Wake-up Test (Stagnara)**

Before the widespread use of electrophysiological monitoring, the intraoperative wake-up test (Stagnara) was the gold standard for monitoring spinal cord integrity. The test involves temporarily lightening anesthesia during surgery, to a degree that the patient can follow simple commands (e.g., squeeze the anesthesiologist’s hands, move your feet), in order to assess corticospinal tract integrity and resulting motor function.

Today, the wake-up test is used as a part of a combination of methods when questions or doubts about the integrity of the motor pathways remain after a neuromonitoring change is detected. Although it is simple to perform and does not require specialized equipment, the wake-up test misses the onset of injury or ischemia, does not identify isolated nerve injury or subtle changes, and puts patients at risk for surgical recall and increased apprehension about surgery.

**Transcranial Motor Evoked Potentials (MEP)**

Transcranial MEP monitors motor pathways in the spinal cord using muscle responses (muscle MEP). This involves 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.

The majority of transcranial MEP recordings are performed to confirm viability of the spinal cord. They may also detect position-related impending central or peripheral nerve (ulnar nerve/brachial plexus) injury. Relative contraindications for transcranial MEP monitoring include epilepsy, cortex lesion, skull defects, high intracranial pressure, intracranial apparatus (electrodes, vascular clips, and shunts), cardiac pacemakers, or other implanted pumps.

The advantages associated with monitoring transcranial MEP include the following: its excellent sensitivity for motor deficit; it directly evaluates the entire motor axis (cortex, corticospinal tract, nerve root, peripheral nerve); and it allows immediate assessment of corticospinal integrity following high-risk maneuvers. Transcranial MEP monitoring also has a number of disadvantages, including the fact that it does not allow for continuous monitoring. In addition, it precludes the use of neuromuscular blockade and causes patient movement, is highly sensitive to anesthetic effects, and carries potential risk for inducing seizures.

**Upper and Lower Somatosensory Evoked Potentials (SSEP)**

Somatosensory evoked potentials provide monitoring of the dorsal column (and possible dorsal spinocerebellar) sensory pathways. In the upper extremity, this involves stimulating a peripheral nerve, usually the median or ulnar nerve near the wrist. Alternate stimulation sites include the radial nerve between the thumb and first finger on the dorsal surface of the hand, and the median nerve or the ulnar nerve at the elbow. The typical site of stimulation in the lower extremity is the posterior tibial nerve at the foot, with alternate stimulation sites including the peroneal nerve at the fibular head and the tibial nerve in the popliteal fossa.

Spinal cord function can be assessed with SSEP monitoring during neurosurgical procedures such as resection of intra- or extramedullary tumors and spinal orthopedic procedures. One of the most common indications for SSEP monitoring is in patients undergoing corrective surgery for scoliosis.

Monitoring SSEP has numerous strengths. It is broadly available and relatively affordable. SSEP monitoring allows continuous monitoring throughout cases and has excellent specificity. It may also be used with neuromuscular blockade. Warning criteria is also firmly established for SSEP (decreased amplitude >50% or increased latency >10% is considered significant). Unfortunately, the averaging of evoked responses leads to significant delays in signal change. Other weaknesses of SSEP include lack of direct monitoring of the corticospinal tract and low sensitivity for motor deficit. In addition, SSEP may remain unchanged with anterior spinal artery injury.
Electromyography (EMG)

Spontaneous EMG monitors selective nerve root function, providing information on the state of the peripheral nerves that innervate a muscle. Compression or stretch of a nerve, as well as hypothermia and ischemia, produce depolarization of the axons, resulting in the appearance of spontaneous action potentials. The action potentials subsequently produce contractions of muscle fibers that can be recorded by electrodes placed in the muscle.

Spontaneous EMG is highly sensitive for nerve root injury, provides constant feedback throughout cases, and may be combined with SSEPs to improve specificity. However, there is a high rate of false positives associated with spontaneous EMG, which is extremely sensitive to temperature changes (cold irrigation or use of cautery). Another weakness of spontaneous EMG is that it precludes use of neuromuscular blockade.

Triggered EMG is used to determine whether lumbar pedicle screws are properly placed. This relies on the concept that intact cortical bone should electrically insulate a well-placed pedicle screw from the adjacent nerve root. With a medial pedicle breach, the pedicle screw would be relatively poorly insulated. By electrically stimulating the pedicle screw directly and electromyographically assessing the lowest threshold value at which CMAPs are generated, the likelihood of medial pedicle breach can be assessed.

Triggered EMG has high sensitivity for medial pedicle breach, is useful in minimally invasive surgery where anatomical landmarks may be challenging to visualize, and is relatively easy to perform and interpret. However, optimal alarm criteria have not been firmly established for triggered EMG. Another disadvantage of triggered EMG is the potential for false-positive alarms if multiple passes have been made through the pedicle or if the operative field is bloody. In addition, triggered EMG only provides information regarding pedicle integrity and does not directly assess for neurological injury.

Both spontaneous and triggered EMG techniques can be used to monitor posterior lumbar, thoracic, and cervical fusions to detect nerve root injury.

Multimodality IOM

Using multiple modalities for IOM may potentially compensate for the limitations of each individual monitoring modality. A combination of SSEP and MEP monitoring may be used for scoliosis surgery for combined monitoring of ascending and descending pathways, and the addition of spontaneous EMG and triggered EMG may enhance the detection of nerve root injuries.

Measuring Performance Outcomes for Spinal Surgeries

The marked increase in the number of spinal surgeries and the use of IOM has led to inconsistencies in the use of the procedures because the medical community has not reached a consensus about which procedures are most effective. Clinical practice is often guided by an understanding of the principles of spinal biomechanics and knowledge of the generally accepted indications, contraindications, and controversies regarding spinal surgeries. Factors to be considered are the patient’s history, physical exam, and response to conservative measures, psychosocial profile, diagnostic test results, and the physician’s expertise.

Compliance With Evidence-Based Guidelines

Intraoperative monitoring is indicated in select spine surgeries when there is risk for additional spinal cord injury. It has not been shown to improve patient outcomes following lumbar decompression or fusion procedures for degenerative spinal disease. Constant communication between surgeon, neurophysiologist, and anesthetist are required for safe and effective IOM.

According to the American Academy of Neurology (AAN), it is expected that a specifically trained technologist or non-physician monitorist, preferably with credentials form 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, either with the physical or electronic capacity for real-time communications with the supervising physician.

In 2008, the American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) issued a position state-
Intraoperative Monitoring During Spinal Surgery

Intraoperative monitoring during spinal surgery is not indicated for routine indications (e.g., lumbar or cervical laminectomy or fusion). Circumstances in which monitoring may be considered medically necessary include myelopathy, scoliosis surgery, and pedicle screw safety monitoring. Health plans state that IOM must be performed by either a licensed physician trained in clinical neurophysiology or a trained technologist, and that IOM must be interpreted by a licensed physician trained in clinical neurophysiology, other than the operating surgeon, who is immediately available to interpret the recording and advise the surgeon.

Proper Documentation

Thorough physician documentation is critical for reimbursement of spinal surgeries and IOM. In addition to office notes, including medical history and physical exam findings, there must be detailed documentation regarding the extent and response to conservative therapy, as well as radiology reports for any imaging studies. In addition to affecting reimbursement, incomplete documentation also can affect patient outcomes and may increase risk of liability and malpractice claims.

Measuring Patient Outcomes

Looking at the length of stay for spinal surgeries is one way of looking at both the efficacy and safety of care. A shorter average length of stay may indicate that patients are recovering more quickly and experiencing fewer complications. However, it is important to consider the nature and extent of the surgery being performed. Other factors to review to assess patient outcomes are complications arising from surgery and unplanned reoperations and readmissions.

Physician Privileging

Privileging is a process that recognizes that a physician is both qualified and competent. It defines a physician’s scope of practice and the clinical services he or she may provide, and it is based on demonstrated competence and is a data-driven process.

Physician privileging involves gathering information with which to decide the types of care, treatment, and services or procedures that a practitioner will be authorized to perform in a specific setting (e.g., hospital), taking into considering setting-specific characteristics, such as adequacy of the facilities, equipment, and number and type of qualified support personnel and resources. Other criteria that determine the practitioner’s qualifications include the physician’s education, training (residency and/or fellowship), and clinical experience (number of procedures performed with satisfactory outcomes).

For IOM credentials at the interpretive level, the American Board of Neurophysiologic Monitoring (ABNM) (www.abnm.info) requires the provider have a doctoral degree, have taken graduate level courses in neuroanatomy and neurophysiology, submit proof of training, and have taken the primary responsibility for interpreting at least 300 cases. Credentialing by the American Board of Clinical Neurophysiology (ABCN) (www.abcn.org) consists of two written examinations open to licensed physicians who are board certified in neurology, neurosurgery, or psychiatry, and who have done at least 1 year of fellowship training in clinical neurophysiology.

For IOM credentials at the interpretive level, the American Board of Neurophysiologic Monitoring (ABNM) (www.abnm.info) requires the provider have a doctoral degree, have taken graduate level courses in neuroanatomy and neurophysiol-
ogy, submit proof of training, and have taken the primary responsibility for interpreting at least 300 cases. Credentialing by the American Board of Clinical Neurophysiology (ABCN) (www.abcn.org) consists of two written examinations open to licensed physicians who are board certified in neurology, neurosurgery, or psychiatry, and who have done at least 1 year of fellowship training in clinical neurophysiology.

Privileging requires qualified and objective physician-controlled peer review, utilizing criteria that have been established through common legal, professional, and administrative practices, endorsed by a formal consensus process, and that are publicly available. These criteria must be directly related to quality of patient care, and documented physician performance should be measured against these criteria. Peer review decisions must be fair and without conflicts of interest and have dated detailed documentation, and should be confidential and protected.

Hospitals with a history or pattern of retaining or contracting with incompetent and low-quality providers may be subject to potential legal liability for any injuries to patients, exclusion from federal and state health benefit program participation, loss of commercial contracts, and loss of accreditation by healthcare standards organizations.

How External Peer Review Helps Hospitals Ensure Quality of Patient Care & Safety

Ongoing evaluation of hospital practitioners ensures excellence in physician performance and the highest standard of care for patients. External peer review allows hospitals to perform not only in-depth evaluation of sentinel events, but also (re)credentialing, (re)privileging, proctoring, and ongoing measurement and monitoring of physician performance. Peer review committees composed primarily of in-house hospital personnel often lack the resources to help the hospital achieve its performance improvement goals, and social and professional relationships lead to conflicts of interest. External peer review avoids conflicts of interest that can arise from economic, professional, or social ties among physicians within a single institution. It may also be an effective solution for hospitals that lack adequate physician resources to conduct timely performance analyses.

When properly executed, external peer review can reduce medical errors through objective evaluations performed in a nonpunitive, educational context that supports a healthy culture of continuous improvement. This results from physicians knowing that their work will be objectively evaluated at regular intervals by board-certified specialists with the same credentials and from similar practice settings, thereby leading to improved quality of care and patient safety. Ongoing evaluation of physicians can also uncover problematic practice patterns, as well as physician- and hospital-level issues that need to be addressed.

External peer review can also play a key role in reducing or eliminating risks associated with increased malpractice claims. Unlike internal peer review, which only looks at sentinel events, external peer review can help hospitals to discover, highlight, and deal with physician performance issues quickly and efficiently before they turn into claims.
Intraoperative Monitoring During Spinal Surgery

Conclusions

Spinal surgery includes a wide variety of procedures that place the spinal cord, nerve roots, and key blood vessels at risk for injury. Intraoperative monitoring allows surgeons to assess the functional integrity of susceptible neural elements during surgery, potentially allowing them to address problems before any damage occurs. The methods used for IOM vary with the type of surgery and the structures at risk. As IOM for spinal surgery continues to evolve, it is critical that surgeons have a solid background in the most up-to-date techniques and clinical applications.

Bibliography


About AllMed Healthcare Management

AllMed provides external peer review solutions to leading hospital groups and ASCs, nationwide. AllMed offers MedEval\textsuperscript{(SM)} and MedScore\textsuperscript{(SM)}, which help facilities improve physician performance through both periodic and ongoing case reviews at the individual or departmental levels. Services are deployed through PeerPoint\textsuperscript{®}, AllMed’s state-of-the-art medical review portal. For more information on how AllMed can help your organization improve the quality and integrity of healthcare, contact us today at info@allmedmd.com.