Evolving Compartment Syndrome Detected by Loss of Somatosensory- and Motor-evoked Potential Signals During Cervical Spine Surgery

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abstract

Neurologic injury is a rare but devastating complication of spinal surgery that can result in mild sensory to severe motor deficits. Surgeons increasingly use electrophysiological spinal cord function monitoring, including somatosensory- and motor-evoked potentials, intraoperatively to provide information about spinal cord function, aid in surgical decision making, improve outcomes, and reduce complication rates. By providing real-time information about the dorsal and anterior motor column function, somatosensory- and motor-evoked potentials signals allow surgeons to reverse noticeable changes and avoid devastating neurologic injuries. Recognizing changes in baseline signals in the setting of known risk factors enables surgeons to correct these risks.

This article describes a case in which somatosensory- and motor-evoked potentials monitoring were lost in the setting of an impending right forearm compartment syndrome during 2-level anterior cervical diskectomy and fusion. To the authors’ knowledge, this is the first reported case of spinal cord monitoring detecting an evolving compartment syndrome during cervical spine surgery. The early changes in signal intensity enabled the surgeon to search for a cause and remedy the situation by removing the infiltrated intravenous line. Without the observed changes in somatosensory- and motor-evoked potentials, it is likely that the compartment syndrome may have progressed to the point of requiring fasciotomy to prevent lasting neuromuscular injury.

This article describes a new cause of changes in electrophysiological monitoring and further displays the usefulness of somatosensory- and motor-evoked potentials monitoring during even routine spinal surgery.

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Neurologic injury is a rare but devastating complication of spinal surgery that can result in mild sensory to severe motor deficits. With improved surgical techniques, the incidence of postoperative sensory and motor deficits has been reported to range from .01% to .05% during complex spinal procedures, such as spinal deformity corrective surgery.1

Surgeons increasingly use electrophysiological monitoring of spinal cord function, including somatosensory- and motor-evoked potentials signals, during spinal surgery to provide intraoperative information about spinal cord function, aid in surgical decision making, improve outcomes, and reduce complication rates. By providing real-time information about the dorsal and anterior motor column function, somatosensory- and motor-evoked potentials signals allow surgeons to reverse noticeable changes and avoid devastating neurologic injuries.

In combination, transcranial motor- and somatosensory-evoked potentials signals have been effective in improving the accuracy of monitoring spinal cord function. Many types of insults can result in intraoperative reductions of greater than 50% or complete loss of somatosensory- and motor-evoked potentials signals during spinal surgery.2-5 Surgeon-related influences, such as compression, stretching, vascular insufficiency, direct trauma, anesthesia, and temperature, can cause changes in signal intensity and cord damage.

Recognizing changes in baseline signals in the setting of known risk factors enables surgeons to correct these risks. Somatosensory-evoked potentials changes that are the result of hypotension, hypothermia, or high levels of anesthetic agents can be reversed by inducing hypertension or hyperthermia, reducing the inhalation of the anesthetic agent, or increasing the levels of inspired oxygen, thereby decreasing the incidence of lasting neurological injury.4 When surgical manipulation or graft placement is the cause, actions can be immediately stopped and corrected to avoid further injury. However, spinal cord monitoring has also been useful in identifying peripheral nerve issues related to malpositioned extremities.

This article describes a case in which the loss of somatosensory- and motor-evoked potentials signals occurred secondary to intravenous infiltration and near compartment syndrome during a 2-level anterior cervical discectomy and fusion. The corrective steps taken intraoperatively prevented a devastating neurologic complication. To the authors’ knowledge, this is the first reported case of spinal cord monitoring detecting an evolving compartment syndrome during cervical spine surgery.

**Case Report**

A 45-year-old man presented with a history of a previous C6-C7 anterior cervical discectomy and fusion for disk herniation and radiculopathy many years before. He subsequently developed a large C4-C5 disk herniation causing cervical myelopathy. He presented with continued bilateral upper-extremity weakness and pain refractory to nonoperative care. He underwent C4-C5 and C5-C6 anterior cervical discectomy and fusion with instrumentation. The patient was positioned on a Jackson table (OSI Medical, Union City, California) with the arms tucked at the side wrapped in egg crate with the ulnar nerves well padded and the wrists in a neutral orientation. Gentle taping was applied to the shoulders to improve visualization on intraoperative fluoroscopy.

A standard Smith-Robinson approach to the cervical spine was performed via a left-sided approach, and the patient’s previous anterior cervical plate was removed. Following plate removal, exploration revealed a solid arthrodesis below the plate. The surgeon (D.J.W.) was notified by the spinal cord monitoring technician of the difficulty in obtaining somatosensory- and motor-evoked potentials from the right hand. Monitoring remained intact in the right deltoid and bicep and the left arm and bilateral legs (Figures 1, 2). Mean arterial pressure was 90 mm Hg, and core body temperature was normal. The surgeon then untaped the shoulders, removed the blood pressure cuff from the right arm, and untucked the right arm to visually inspect the forearm and hand.

On removal of the blood pressure cuff and untucking of the arm, it was observed that the intravenous line had infiltrated into the forearm, resulting in significant

![Figure 1: Somatosensory-evoked potentials signals monitoring showing loss of somatosensory-evoked potential signal in response to right ulnar nerve stimulation. Abbreviation: IV, intravenous line.](image-url)
swelling, at which point the intravenous line was removed. Compartment pressures of approximately 28 to 30 mm Hg were measured in the superficial and deep volar compartments, whereas the dorsal compartment and mobile wad of Henry were normal. After 30 minutes of observation, the swelling began to improve, and the somatosensory- and motor-evoked potentials signals returned to near baseline.

The procedure was resumed with no further complications. Postoperatively, the patient moved all 4 extremities. He reported some forearm tightness but no tingling, paresthesias, weakness, or signs suggestive of compartment syndrome.

**Discussion**

Intraoperative monitoring of somatosensory-evoked potentials allows surgeons to promptly correct signal changes and is associated with decreased morbidity and better outcomes. According to Nuwer et al, somatosensory-evoked potentials monitoring can detect more than 90% of neurological deficits as they occur in the operating room, and an experienced monitoring team can reduce the incidence of neurological deficits by 50% and major deficits by a greater percentage.

Somatosensory-evoked potentials monitoring has limitations. Because somatosensory-evoked potential signals represent sensory pathways in the posterior and posterolateral regions of the spinal cord, a lesion or vascular insult to the anterior region of the cord with preservation of the blood supply posteriorly will result in spinal cord dysfunction posteriorly. However, somatosensory-evoked potentials monitoring can detect and provide information about the anterior aspect of the cord where the motor tracts are primarily located.

Vitale et al reported the usefulness of combined monitoring. The records of 162 patients who underwent surgery for spinal deformity were analyzed. They reported that changes in electrophysiological signals had a specificity of 87.9% and a sensitivity of 100%, where all postoperative neurological deficits were preceded by changes in signal intensity. In addition, no deficits occurred in motor function following a procedure with normal motor-evoked potentials. These results were consistent with the study by Pelosi et al, which showed a similar sensitivity and specificity of combined monitoring.

Intraoperative somatosensory-evoked potentials monitoring is also useful for detecting problems unrelated to the manipulation of the spinal cord itself. Somatosensory-evoked potentials can be used to determine position-related impending brachial plexus injury because changes in nerve conduction generally occur before permanent injury. Thus, the neurophysiological recordings can alert surgeons or anesthesiologists to alter the arm position before lasting injury occurs. In a study of 230 patients undergoing posterior lumbosacral spinal procedures, somatosensory-evoked potentials monitoring of the upper limb was effective at identifying impending position-related brachial plexus injury. In 14 of 21 patients with significant somatosensory evoked potentials intraoperatively, repositioning of the arm resulted in signal restoration to near baseline, and no deficits were observed postoperatively. The authors reasoned that monitoring upper limb somatosensory-evoked potentials can reduce position-related nerve injury, especially in patients at a greater risk for upper arm compression, such as those who are obese. The current patient is another such example of the benefit of somatosensory-evoked potentials monitoring in detecting iatrogenic causes of potential nerve injury.

Nonspinal surgery can also benefit from somatosensory-evoked potentials monitoring. Peripheral nerve monitoring using somatosensory-evoked potentials recordings during external fixation procedures of the lower extremities has been a reliable method to detect impending nerve injury. In addition, a retrospective
study by Baumgaertner et al\(^9\) showed that somatosensory-evoked potentials monitoring is helpful in detecting and preventing nerve root injuries for patients undergoing surgery for pelvic or acetabular fractures. In the study of 40 patients, the incidence of new postoperative neurological deficits was 5% in the monitored group and 24% in the unmonitored group, with the difference approaching significance (\(P=0.9\)). Five of 6 patients with surgically induced somatosensory-evoked potential changes reverted to baseline tracings after the surgeon was notified and made the appropriate corrections. Postoperatively, none of the 5 patients had postoperative deficit, demonstrating the usefulness of somatosensory-evoked potentials monitoring during even nonspinal procedures.

**Conclusion**

In the current case, somatosensory- and motor-evoked potentials signal monitoring were lost in the setting of an impending right forearm compartment syndrome. The early changes in signal intensity enabled the surgeon to search for a cause and remedy the situation by removing the infiltrated intravenous line. Without the observed changes in somatosensory- and motor-evoked potentials signals, it is likely that the compartment syndrome may have worsened and progressed to the point of requiring fasciotomy to prevent lasting neuromuscular injury rather than simple observation. The authors described a new cause of changes in electrophysiological monitoring and further displayed the usefulness of somatosensory- and motor-evoked potentials monitoring during routine spinal surgery.

**References**