

# Acute Hypotension in a Patient Undergoing Posttraumatic Cervical Spine Fusion With Somatosensory and Motor-Evoked Potential Monitoring While Under Total Intravenous Anesthesia: A Case Report

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*Hypotension should be vigilantly prevented in patients with spinal cord injury. Recent advances in neurological, intraoperative monitoring techniques have allowed Certified Registered Nurse Anesthetists to assess the effects of spinal cord ischemia and compression as they occur.*

*This case report describes a young, healthy man who sustained a cervical spine fracture and was scheduled for anterior spinal fusion with somatosensory and motor-evoked potential (MEP) monitoring while under total intravenous anesthesia. This patient experienced*

*a brief period of intraoperative hypotension with evidence of abnormal MEPs. A wake-up test was performed, which showed normal functioning, and the case resumed an uneventful course. Although this scenario resulted in no neurological sequelae, the effects of spinal cord ischemia due to hypotension can lead to permanent, devastating motor and sensory damage.*

**Keywords:** Cervical fusion, hypotension, motor-evoked potential, somatosensory evoked potentials, total intravenous anesthesia.

Approximately 11,000 new cases of spinal cord injury occur each year in the United States.<sup>1</sup> Surgical stabilization has become a safe, reliable means of correcting spinal injuries. Accompanying the advances in spinal surgery are the clinical advances in neurological monitoring techniques. Somatosensory evoked potential (SSEP) monitoring and the more recent advancement of motor-evoked potential (MEP) monitoring have been implemented in many institutions where complex spinal, neurological, and vascular procedures are performed. With these advancements in monitoring come unique anesthetic challenges that redirect anesthetists from their customary techniques of general anesthesia with the use of neuromuscular blockade. Total intravenous anesthesia, the technique customarily used in our academic facility to allow for SSEP and MEP monitoring, offers the anesthetist the challenge of maintaining a motionless patient while preventing a hypotensive response.

## Case Summary

A 41-year-old man who had sustained a cervical fracture at the level of the C6 vertebra was scheduled for an anterior cervical fusion with somatosensory and motor-evoked potential monitoring. His medical history was remarkable only for tobacco use at 1 pack per day for 25 years. Before his admission he was on no medications, had no allergies, and his surgical history involved tonsil-

lectomy and adenoidectomy at the age of 7 without complication. He reported that he was 6 ft, 1 in, tall, and weighed approximately 190 lb. The patient denied a history of cardiovascular, neurological, pulmonary, gastrointestinal, or endocrine disease. He sustained the current injury in a snowmobile accident 1 day before the surgery and was given adequate fluid resuscitation in the preoperative period as evidenced by hemodynamic stability, appropriate urinary output, and lack of signs of hypovolemia.

The patient was in the operating room evaluation area sitting upright in bed with a rigid cervical collar in place. He was awake, alert, and cooperative. He sustained no head, chest, abdominal, or extremity trauma. His lungs were clear bilaterally; heart sounds revealed audible S<sub>1</sub>, S<sub>2</sub> without murmur. The patient denied parathesia and was able to move all extremities equally on command. He reported bilateral lower extremity pain, more on the right side than the left, reaching pain scale levels of 9 on a scale of 1 to 10. He had 2 large-bore intravenous lines. The laboratory results from the operative day morning were all within normal limits. The last recorded vital signs were: blood pressure, 106/74; heart rate, 82/min; respirations 18/min, and room air saturation of 99%. There were 4 units of cross-matched packed red blood cells available. After a brief discussion, the anesthesia team, the neuro-monitoring technician, and the attending surgeon, agreed that total intravenous anesthesia without the use of para-

lyzing agents was the most appropriate method. The CRNA and the attending anesthesiologist agreed that an awake, fiberoptic laryngoscopy was the safest way to secure the airway and that invasive monitoring was not required because of the lack of a cardiac history.

Informed consent was obtained, including an explanation of the possibility of an intraoperative wake-up test, before the patient was brought to the operating room. With the cervical collar in place, the patient was then given intravenous midazolam, 2 mg, for anxiolysis. All noninvasive monitors (blood pressure cuff, electrocardiogram, pulse oximeter) were applied, and baseline vital signs were obtained. His vital signs were: blood pressure 111/80 (101 mm Hg); heart rate, 88/min; respirations, 20/min; and room air saturation of 99%. Aerosolized 4% inhaled lidocaine and a bilateral superior laryngeal nerve block with 3 mL of 2% lidocaine and a transtracheal block with 3 mL of 4% lidocaine were administered. Direct fiberoptic oral laryngoscopy was performed, and the airway was secured while a stable cervical spine was maintained. After the airway was secure, the patient demonstrated that he could move all extremities on command and was then anesthetized with a 60-mg bolus of propofol. The neurological monitoring technician then applied all of the appropriate monitors needed to assess SSEP and MEP.

Maintenance of anesthesia was accomplished with a baseline rate of propofol, 150 µg/kg per minute, and fentanyl, 1.5 µg/kg per hour. Blood pressure, which was cycled every 2 minutes, remained at or slightly below baseline with a mean arterial pressure range of 82-100 mm Hg. A 50-µg bolus of fentanyl and 20-mg bolus of propofol were given with the surgeon-administered local anesthesia 1 minute before the application of the head pins to blunt the sympathetic response to the stimuli. Blood pressure increased to 120/84 mm Hg (108 mm Hg) with the application of the pins.

Approximately 7 minutes after the initial bolus, while the same baseline rates of intravenous anesthesia were maintained, the patient coughed in response to positioning. Because of the nature of the injury, and because the patient was about to be put in cervical traction, the unwanted movement had the potential to create major complications. The blood pressure reading during the period when the patient coughed was 131/74 mm Hg (112 mm Hg). A 30-mg bolus of propofol was immediately administered. Patient movement in response to the painful stimuli had ceased, leading to the belief that the bolus was effective. Approximately 90 seconds after the 30 mg propofol bolus, the patient showed a blood pressure reading of 71/50 mm Hg (64 mm Hg). The blood pressure was immediately treated with 15 mg of ephedrine; 60 seconds later a blood pressure reading of 102/78 mm Hg (94 mm Hg) was noted. A 500-mL crystalloid bolus was administered in addition to the baseline intravenous rate.

During the hypotensive episode, the neurological monitoring technician reported his initial, baseline MEP reading. Concerned about possible motor impairment secondary to hypotensive cord ischemia, the surgeon requested that a wake-up test be performed. The anesthetics were stopped and after approximately 15 minutes, the patient was able to respond to commands by moving all extremities. The surgery resumed without further hypotension or complication, although the MEP reading maintained the abnormal values that were initially reported. Although the hemodynamics were corrected, there was not evidence of a change in the MEP reading that would suggest a correction in the motor functioning. Maintenance of anesthesia was achieved with varying rates of propofol and fentanyl and with 2 boluses of phenylephrine, 40 µg, when hypotension seemed imminent. The patient was extubated in the operating room at the end of the 5.5-hour surgery and demonstrated no motor deficits. The patient reported no recollection of the wake-up test.

## Discussion

Mechanical or ischemic damage to the spinal cord is a complication that accompanies complex spinal surgeries. The incidence of severe postoperative neurologic sequelae has been reported to be 0.46% for anterior cervical procedures.<sup>2</sup> These complications can be detected and possibly prevented by employing techniques of evoked potential monitoring. Somatosensory evoked potentials are generated by applying a stimulus to a peripheral nerve and tracking its progression through the sensory pathway. The median, ulnar, posttibial, and peroneal nerves are typically used as sites of stimulation while surface electrodes interpret signals from peripheral nerves, plexuses, nerve roots, dorsal columns, and the sensory cortex. Motor-evoked potentials provide a means of assessing the descending motor pathways and are typically obtained by transcranial electrical stimulation.<sup>3,4</sup>

It has been suggested that monitoring of both somatosensory and motor function simultaneously at more than 1 level is the most effective way of increasing the sensitivity and providing artifactual control in recording conditions.<sup>5</sup> Costa et al<sup>2</sup> performed a prospective, observational study of 52 patients recording MEPs and SSEPs undergoing spinal cord surgery with total intravenous anesthesia by propofol and fentanyl infusion. They were able to determine that these monitoring techniques, when performed together, provide a safe, reliable, and sensitive method to detect and reduce intraoperative injury to the spinal cord. A study by Pelosi et al<sup>6</sup> supported the findings of Costa that these are effective techniques that are best administered simultaneously but concluded that these advancements eliminate the need for an intraoperative wake-up test.

Traditional general anesthesia techniques with neuro-

muscular blockade are incompatible with these types of neurological monitoring. All anesthetics affect evoked potentials to some extent. It has been suggested that intravenous techniques should be employed when monitoring SSEP because inhaled anesthetics will eliminate cortical responses, causing a dose-dependent increase in latency and decrease in amplitude. Accepted research describes how MEPs are extremely sensitive to nitrous oxide and volatile anesthetics and will attenuate and abolish myogenic responses.<sup>7,8</sup> A prospective study with 25 patients in 2002 by Strahm et al<sup>9</sup> showed that by using total intravenous anesthesia, the impact of the intravenous medications can be reliably anticipated and taken into consideration, allowing for effective evoked potential monitoring throughout the surgery. Although there are numerous combinations of intravenous anesthetics and analgesics, the most-cited technique involves a propofol infusion with either fentanyl or remifentanyl.

In this case, the patient was given a 50- $\mu$ g bolus of fentanyl and a 20-mg bolus of propofol immediately before the application of the head pins, which are required for intraoperative cervical traction. The sympathetic response was blunted as evidenced by only a slight increase in heart rate and blood pressure. Over the next several minutes, there was a period of nonstimulation to the patient during which his vital signs returned to the anesthetized baseline. The stimulus of positioning that came next caused a coughing response, possibly due to endotracheal tube manipulation. While the patient was coughing, the blood pressure cuff was cycling and read 131/74 mm Hg (112 mm Hg). The response to the patient movement was to administer a bolus of 30 mg of propofol immediately, which ended the patient's cough reflex and movements. As a result of the bolus, the next cycled blood pressure reading, 2 minutes following the last reading, was 71/50 mm Hg (64 mm Hg). The low blood pressure was treated immediately with 15 mg of ephedrine followed by a fluid bolus and was returned to baseline less than 2 minutes after the hypotensive reading. The patient was hypotensive for approximately 60 to 90 seconds.

A decrease in systemic blood pressure reduces spinal cord perfusion therefore increasing the likelihood for neurologic deficits and altered evoked potential signals.<sup>10</sup> An important component of anesthetic management is the preservation of spinal cord blood flow and careful maintenance of the cord perfusion pressure. Pelosi et al<sup>6</sup> describes 3 case reports of patients losing MEPs during periods of transient hypotension. The MEPs of 2 patients returned to baseline with no postoperative deficits, but 1 patient awoke from surgery paralyzed. Although there are no prospective controlled studies on the effects of hypotension on outcomes of spinal cord injury, because of apparent associations of negative outcomes, guidelines have been implemented recommending maintenance of

mean arterial pressure at 85 to 90 mm Hg.<sup>11</sup> Prompt treatment of hypotension with restoration of blood volume or vasopressive therapy is the recommended means for accomplishing this.<sup>12</sup>

Before the introduction of intraoperative neurological monitoring, the surgical team had relied solely on the wake-up test to assess motor function. This involved discontinuation of surgical anesthesia until the patient was able to respond appropriately by moving his hands and feet on command. False negative results, meaning the patient passed the wake-up test but ultimately had negative outcomes, were infrequent enough that this test was deemed a reliable predictor of outcome. This test, however, did present some complications of its own, such as up to 20% incidence of recall and excessive patient movements during the awake period. The test also required a cooperative patient who could follow commands, which rules out many pediatric patients.<sup>3,13</sup> Although the wake-up test has fallen out of favor in many institutions because of the advancements in neuromonitoring techniques, it is still considered a highly reliable means to assess intraoperative motor function.

In this case, the neurologic monitoring technician reported an absence of motor-evoked potentials in sporadic locations and no abnormalities in SSEP. This report, it was later learned, was the initial reading of MEP and there was no baseline to use as comparison. Because this report came during the hypotensive event, it was determined, appropriately, that a wake-up test be performed to rule out an ischemic motor deficit. The MEP evaluation for this patient showed a false positive result, meaning that the test indicated a deficit when none was present. False positive results are tolerated for MEP and SSEP because they err on the side of safety. A study by Taunt et al<sup>14</sup> revealed a false positive rate of 1.8% of the 163 participants undergoing SSEP monitoring for anterior cervical discectomy. The surgical course for this patient proceeded as planned, with maintenance of anesthesia accomplished with infusions of propofol and fentanyl at varying rates. On 2 occasions 40  $\mu$ g boluses of phenylephrine were used to treat an anticipated hypotensive event as evidenced by a downward trend in cuff pressures. The basal rates of the intravenous anesthetics were adjusted to prevent further decreases in arterial blood pressure. The patient had minimal blood loss and was awakened from anesthesia and extubated in the operating room immediately following the case. The patient demonstrated appropriate motor and sensory responses immediately following extubation. His postoperative course was uneventful and his pain was controlled adequately with intravenous patient-controlled analgesics. He reported no recollection of the awake fiberoptic laryngoscopy or the wake-up test. The patient was discharged on postoperative day 4.

Anterior cervical fusion surgery under total intra-

venous anesthesia presents unique risks. Patient movement due to lack of muscle relaxant can have devastating consequences. There have been studies showing the ability to monitor MEPs while administering desflurane and nitrous oxide. Lo et al<sup>11</sup> demonstrated this in a 2006 study of 20 patients by suggesting that similar monitoring results were obtained by using desflurane/nitrous oxide as were obtained with total intravenous anesthesia, providing that the MEPs were monitored by the abductor hallucis as opposed to the tibialis anterior with the desflurane test. Improvements in monitoring precision and allowable levels of anesthesia are needed to decrease the risks associated with this procedure.

## Conclusion

Effective communication among the surgical, anesthesia, and neuromonitoring teams is an essential component of maintaining a safe operating environment. Better communication among all specialties involved in the care of this patient would have decreased the risk of adverse outcomes. Invasive blood pressure monitoring should be present in any case that requires strict hemodynamic management, and a bispectral index monitor, although not a true predictor of patient movement, would have been a valuable tool in assessing depth of anesthesia. The surgical team should be encouraged to give the anesthetist advanced notice of stimulating events such as application of head pins or patient positioning. The neuromonitoring team should be encouraged to report baseline results of MEPs and SSEPs as they are obtained. The anesthesia team should be reporting periodic mean pressures to the surgeon and should be cautious in responding to acute episodes of movement in the same manner as would be done with a patient who does not have an increased risk for hypotensive spinal cord ischemia.

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