**Title:** Decreased Amplitude and Increased Latency in OR Communication During Anterior/Posterior Spinal Fusion

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**Goals:**
1. Understand the basics of Neuromonitoring
2. Appreciate the effects of anesthetic agents on SSEPs and MEPs
3. Recognize the need for appropriate communication between OR personnel
4. Develop strategies for delivering bad news, and post-event management

**Case history:**
An obese 10 year old female (60 kg, BMI 38 greater than 99% for age) with severe idiopathic scoliosis presented for T3-L1 anterior-posterior spinal fusion.

**Questions:**
What are the anesthetic implications of scoliosis? What additional history and physical exam findings would you seek before proceeding with the case? What laboratory test would you request? Does the severity of the curve affect the risk of anesthesia?

**Surgical Plan:**
An anterior T6-T11 discectomy via right thoracotomy, followed by posterior spinal fusion. Spinal cord integrity monitoring with somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs) was planned. The surgeon tells you that he wants the patient awake at the end of the operation so that he may assess her neurological function.

**Questions:**
What monitors would you plan to use? What discussions would you have with the family: anesthetic and/or surgical risk, neuromonitoring, and/or possible wake-up test? Do you involve the parents and child or just the parents?

**Intraoperative Management:**
Anesthesia was induced with sevoflurane via facemask, intravenous access times two was established and the trachea was intubated. A radial arterial line was placed for hemodynamic monitoring and serial arterial blood gas analysis. Anesthetic maintenance proceeded with propofol and remifentanil infusions and half MAC desflurane to facilitate neuromonitoring. Baseline SSEP and MEP signals were obtained in the supine position. The right lung was isolated with a bronchial blocker to improve surgical exposure. After 3 hours and completion of the anterior thoracic discectomies, the patient was turned to the prone position for the posterior T3-L1 fusion.

**Questions:**
Should ideal or actual body weight be used for drug dosing? Is the volume of distribution altered in obese individuals? How does the choice of anesthetic technique affect the reliability of neuromonitoring and the ability to conduct a wake up test if
needed? What variables affect the SSEP/MEP signals? Is it possible to have normal SSEPs with altered MEPs?

**Intraoperative Management (continued):**

The case proceeded for 3 more hours, during which there was moderate blood loss (20 mL/kg). Cell saver was used to salvage blood from the surgical field to return to the patient. The patient’s MAP remained above 60 mmHg (preoperative baseline 75 mmHg) and serial arterial blood gases revealed a hemoglobin above 7.5 g/dL (baseline 11.5 g/dL).

**Questions:**

What strategies would you use to minimize intraoperative blood loss and transfusion requirements? What are the risks associated with these strategies when used during a spinal fusion? What factors influence your decision to transfuse? What hemodynamic parameters should be maintained during a spinal fusion?

**Intraoperative Management (continued):**

After hardware placement, the neurophysiologist requested that the anesthesia team “decrease” the anesthetic. On further questioning, it was discovered that there were ongoing MEP changes that the neurophysiologist attributed to “deep anesthesia” and therefore did not mention to either the surgeons or the anesthesiologist. Another neurophysiologist arrived and determined that the MEP changes from baseline actually occurred after turning prone, three hours ago! The propofol and remifentanil infusions were reduced by 50%. 30 minutes later, despite these decreases, there were still no improvement of the MEPs.

**Questions:**

How should the anesthesia team respond to changes in the evoked potentials from baseline? Is it appropriate to assume that the changes are due to “deep anesthesia”? What information, in addition to the anesthetic parameters, is needed from the neurophysiologist and/or the surgeon in order to construct a differential diagnosis?

**Intraoperative Management (continued):**

Because of the uncertainty regarding the integrity of the neuromonitoring, a wake-up test was requested. Despite following other commands, the patient did not move her lower extremities. The hardware was removed and the patient underwent an urgent MRI that showed no focal spinal cord compression. The patient was given PRBCs to increase tissue oxygen delivery and 30mg/kg methylprednisolone to reduce spinal cord edema, the MAP returned to the baseline un-anesthetized state.

**Questions:**

Where and why did the communication break down? What is the role of “post-event” debriefing with the involved team members? How do you prevent this from happening again? Who should go talk to the parents, what should they say? How do you deliver bad news to people with whom you have formed little or no relationship?
Discussion:

Somatosensory and motor evoked potentials (SSEP and MEP) are commonly used during scoliosis corrective surgery to monitor spinal cord integrity. Use of neuromonitoring is associated with a reduced incidence of neurological deficits after scoliosis surgery. An understanding of neuromonitoring principles is important in order for the anesthesia team to appropriately respond to intraoperative monitoring changes.

SSEPs monitor the integrity of the ascending dorsal columns of the spinal cord by stimulating a peripheral nerve and measuring the sensorimotor cortex response. Conversely, motor evoked potentials (MEPs) monitor the integrity of the descending anterior columns of the spinal cord by stimulating the cortical motor tracts and measuring the direct motor response. Because the anterior (motor) and posterior (sensory) aspects of the spinal cord are perfused by separate blood supplies, loss of motor function can occur without loss of sensory function or changes in SSEPs. MEP monitoring was developed specifically to assess the integrity of motor pathways of the spinal cord (a limitation of SSEP monitoring). Decreases in spinal cord perfusion and/or tissue oxygenation may result in SSEP and/or MEP signal changes.

There are multiple drugs used in the perioperative period that affect SSEP and MEP monitoring. Currently used volatile agents cause a dose-dependent increase in latency and decreases in amplitude of cortical SSEP signals. In neurologically normal patients, 0.5-1 MAC total (nitrous oxide plus volatile agent) end-tidal inhaled anesthetic concentration is compatible with adequate monitoring of cortical SSEPs. Nitrous oxide causes decreases in amplitude without significant changes in SSEP latency when used alone or when added to a narcotic-based or volatile anesthetic. Although volatile anesthetics cause significant changes in the SSEP waveforms, it is possible to provide adequate monitoring intraoperatively with the use of these agents; however, better monitoring conditions are obtained with narcotic-based anesthetics combined with less than 1 MAC total end-tidal inhaled agent(s) concentration. If potent inhaled anesthetics and/or nitrous oxide are used, the anesthetic concentration should not be changed during critical periods of surgical intervention.

In general, narcotics cause dose-dependent increases in latency and decreases in amplitude of SSEPs, but these changes are not usually clinically significant. Effects on the amplitude are more variable than on the latency increases. As with the inhalational agents, large intravenous boluses of opioids (with resultant evoked potential changes) should be avoided at times of potential surgical compromise. Propofol induction produces amplitude depression in cortical SSEPs with rapid recovery after termination of the infusion. When the SSEP is recorded in the epidural space, propofol has no notable effect. Studies with electrical or magnetic elicited MEPs have demonstrated depressant effect on response amplitude, consistent with a cortical effect. Although propofol does not appear to enhance cortical responses, rapid metabolism allows rapid adjustment of the depth of anesthesia and the effects on evoked responses. As a component of TIVA, infusions of propofol have been combined with opioids and have produced acceptable conditions for monitoring of cortical SSEPs and myogenic MEPs.

Midazolam has the desirable property of amnesia and has been used for monitoring cortical SSEPs. Midazolam, in doses consistent with induction of anesthesia (0.2 mg/kg) and in the absence of other agents, produces a mild depression of cortical SSEP and minimal effects on subcortical and peripheral components. Midazolam also produces prolonged, marked depression of MEPs. Based on several case reports and small series, dexmedetomidine appears to be compatible with all types of evoked potential monitoring and does not produce changes that would be mistaken for surgically induced changes. Etomidate causes increases in latency of all waves and prolongation of central conduction time in SSEPs. However, in contrast to all other
commonly used anesthetics, etomidate increases the amplitude of cortical SSEPs.\textsuperscript{12, 13} Etomidate has been used to enhance SSEP recordings in patients when reproducible responses are not obtained at the onset of intraoperative monitoring due to the patient’s pathology.

Typical anesthetic techniques will produce prohibitive depression of the MEPs.\textsuperscript{14, 15} Investigators have shown that intravenous agents produce significantly less depression of the MEPs than volatile agents. A variety of techniques using ketamine, opiates, etomidate, propofol and dexmedetomidine have been described.\textsuperscript{16, 17, 18} Most studies support the use of total intravenous anesthesia as preferable to techniques using nitrous oxide and/or potent inhaled agents. As with SSEPs, precise control of the anesthetic and avoidance of boluses during critical monitoring periods is crucial and active cooperation and communication between the surgical, anesthesia and neuromonitoring teams is essential to conduct successful neuromonitoring.

Like intraoperative neurophysiologic monitoring, adequate team communication can have a significant impact on outcomes. The development of paraplegia in a child undergoing spinal fusion is a catastrophic event. With multiple teams involved, the possibility of major communication failures exists. Significant lapses in communication are likely to contribute to adverse events. Negative outcomes resulting from poor communication underscore the importance of effective communication among team members caring for patients undergoing surgery.

Communication failures are a common cause of inadvertent patient harm. Operating rooms are complex environments where teams interact with technology.\textsuperscript{19} Poor communication among the surgeons, anesthesiologists, nurses and technicians may lead to adverse events that compromise patient safety. Effective communication and teamwork is essential to deliver high quality, safe patient care. The complexity of medical care in the operating room, coupled with the inherent limitations of human performance, make it critically important that clinicians have standardized communication tools, create an environment in which individuals can speak up and express concerns, and share common “critical language” to alert team members to unsafe situations.

Use of a standardized pre-operative time-out checklist has been shown to improve intraoperative communication and reduce errors. The time-out including all members of the OR team, should include a discussion of the critical aspects of the upcoming case. This approach has demonstrated that team members feel empowered to communicate their concerns and that the channels of communication are open when adverse events occur.

As physicians, we are sometimes responsible for delivering bad news to patients and families, yet traditionally little formal training has existed to develop these skills. Anesthesiologists in particular may have little time to develop meaningful relationships with patients or families in the preoperative period. This lack of relationship makes delivering bad news even more difficult.
References:


