

# Highlights of Anesthetic Considerations for Intraoperative Neuromonitoring

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## Abstract

Though relatively new, intraoperative neurophysiological monitoring (IONM) has become standard of care for many neurosurgical procedures. The use of IONM has substantially decreased the rate of paralysis after deformity surgery, and has been validated in cervical spine surgery, and thoracic and lumbar laminectomy ((1) (2), (3). The main modalities are: somatosensory evoked potentials (SSEPs), motor evoked potentials (MEPs), and electromyography (EMGs). Each test examines a functionally separate area of the spinal cord, which test is chosen depends on the location of the surgery and the patient's preexisting injuries and deficits (6). Inhaled anesthetics decrease the waveform amplitude and increase latency, intravenous anesthetics have the same effect but to a lesser degree. Best anesthetic regimen for surgery involving intraoperative monitoring is controversial. Both inhaled and intravenous agents depress signal attainment, however for equal MAC concentrations inhaled agents cause more depression(11).

While studies have shown that halogenated agents and nitrous oxide do in fact depress MEP signals more than total intravenous anesthesia, less is known on the relationship between IONM and patient characteristics. Lo's study documenting MEP attainment with 0.5 MAC was done in an otherwise healthy scoliosis population (12), and no study to date has analyzed signal attainment in correlation with patient characteristics and anesthetic technique. While it is clear that anesthetic technique is extremely important, certain patient characteristics appear to be more common in difficult to monitor patients. The identification of these characteristics would suggest to the anesthesiologist the need for a more stringent technique (TIVA) and avert surgical delay or cancellation due to inability to obtain baseline or worse- loss of intraoperative waveform and need for a Stagnara wake-up test. Our group at Mt. Sinai has retrospectively studied patient characteristics, anesthetic technique and attainment of neuromonitoring signals. Hypertension and diabetes are independent predictors of monitoring failure, and these are preferentially sensitive to inhalational agents. Age and weight are also predictors, but less significant.

In summary, neurophysiologic monitoring has evolved to be a consistent part of many procedures. The anesthesiologist should strive to understand the rationale behind monitoring and the basis of its utility. IONM has many implications for anesthetic technique and need for control of the physiologic milieu. With this knowledge the anesthesiologist can work together with the neuromonitoring team and surgeon to ensure patient safety during and after surgery.

## Keywords

neuromonitoring, spine surgery, Total Intravenous Anesthesia (TIVA)

Though relatively new, intraoperative neurophysiologic monitoring (IONM) has become standard of care for many neurosurgical procedures. The use of IONM has substantially decreased the rate of paralysis after deformity surgery, and has been validated in cervical spine surgery, and thoracic and lumbar laminectomy.<sup>1-3</sup> Prior to common use of IONM, surgeons relied on the Stagnara wake-up test or ankle clonus. The disadvantage of these tests is they are disruptive to the surgery and potentially dangerous and traumatic to the patient, and neither test can be done continually.<sup>4,5</sup> In modern-day procedures, the spinal cord is tested continually and with minimal risk to the patient throughout many neurosurgical procedures. IONM refers to a group of testing

measures, which allow continual observation of the integrity of the spinal cord during surgery. The main modalities are: somatosensory-evoked potentials (SSEPs), motor-evoked potentials (MEPs), and electromyography (EMGs). Each test examines a functionally separate area of the spinal cord, which test is chosen depends on the location of the surgery and the patient's preexisting injuries and deficits.<sup>6</sup>

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Initially, SSEPs were used alone to monitor the integrity of the dorsal columns. However, it has been well documented that it is possible to injure the anterior motor portion of the spinal cord and get delayed or no change in SSEP signals.<sup>7-9</sup> Therefore, MEPs are employed in combination with SSEPs to afford a higher sensitivity for anterior spinal cord injury.<sup>9</sup> Similar to EEG, both SSEP and MEPs are sensitive to pharmacologic and physiologic factors. Any drug or physical parameter that changes impulse conduction along an axon may change the evoked potential waveform. Not all monitoring modalities are equally sensitive to anesthetic technique. In general, longer pathways with more synapses are more sensitive. MEPs are in general more sensitive to anesthetics than SSEPs.<sup>10</sup> Furthermore, lower extremity signals are more difficult to obtain than signals from the upper extremity—secondary to the proportionally larger representation of the hand on the motor cortex. Thus, the most difficult signals to obtain are the lower extremity MEPs (excluding patients with preoperative deficit who are not expected to have intact signal pathways).

Inhaled anesthetics decrease the waveform amplitude and increase latency, intravenous anesthetics have the same effect but to a lesser degree. The best anesthetic regimen for surgery involving intraoperative monitoring is controversial. Both inhaled and intravenous agents depress signal attainment, however for equal MAC concentrations inhaled agents result in greater signal depression.<sup>11</sup> It has been shown in scoliosis patients that less than 0.5 MAC (minimum alveolar concentration) of inhalational agent should allow for IONM<sup>12</sup> and even concentrations up to 1 MAC have been described as compatible with monitoring.<sup>13</sup> In this school of thought, intravenous agent is used for supplementation as necessary. Others feel that total intravenous anesthesia (TIVA) should be used because it most dependably allows signal attainment. However, total intravenous anesthesia is often costly, requires a multi-channel infusion pump or multiple infusion pumps, and may not be as rapidly titratable.

Previous studies have quantified the effects of anesthesia during IONM.<sup>11</sup> Pechstein et al<sup>14</sup> found that distinct motor responses were recorded in 88% (15 of 17) of patients undergoing total intravenous anesthesia and in only 8% (1 of 13) of patients undergoing anesthesia with nitrous oxide as well as halogenated inhalational agents. Pelosi et al<sup>15</sup> found that MEPs could be recorded in 97% of patients undergoing anesthesia with propofol and nitrous oxide (29 patients total) and in only 61% of patients undergoing anesthesia with isoflurane and nitrous oxide (23 patients total). However, other studies in healthy scoliosis patients did not find a significantly detrimental effect of inhalational agents.<sup>12</sup>

In any case the safest plan is to create a stable anesthetic milieu prior to baseline signal attainment and not vary the technique throughout the procedure. Conceptually this is

simple but in practice more difficult. An adequate plane of anesthesia in the earlier phases of dissection may not be adequate during instrumentation. The potential risk of a bolus of anesthetic is acute loss of neuromonitoring signals at a critical time in the surgery. Obviously the risk of inadvertent extubation, loss of intravenous lines, or other trauma outweighs this, but with some strategy often the situation is preventable. The anesthesiologist must attempt to choose a drug with a rapid onset with the least effect on the evoked potentials. Good choices include small amounts of propofol or fentanyl in combination with ketamine or etomidate as necessary. Communication regarding change in anesthetic technique or bolus administration is important. Signal depression from an anesthetic agent would be global in nature, whereas true injury may be specific to the surgical area. Additionally, a structure with poor signals at baseline may be more affected by anesthetic technique. Recovery of signals from injury and anesthetic technique may require time. The amount of time for recovery of signals from anesthetic technique may be thirty minutes or more. During this time it would not be possible to detect whether there was a concomitant surgical injury.

Although these studies have shown that halogenated agents and nitrous oxide do in fact depress MEP signals more than total intravenous anesthesia, less is known on the relationship between IONM and patient characteristics. The study by Lo et al<sup>12</sup> documenting MEP attainment with 0.5 MAC was done in an otherwise healthy scoliosis population, and no study to date has analyzed signal attainment in correlation with patient characteristics and anesthetic technique. Although it is clear that anesthetic technique is extremely important, certain patient characteristics appear to be more common in difficult to monitor patients. The identification of these characteristics would suggest to the anesthesiologist the need for a more stringent technique (TIVA) and avert surgical delay or cancellation due to inability to obtain baseline or worse—loss of intraoperative waveform and need for a Stagnara wake-up test.

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