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Individualized Intraoperative Neuromonitoring for Addressing Challenges in Cervical Spine Surgery: Valuable Lessons from a Case

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ABSTRACT

Introduction: Intraoperative monitoring (IONM) during spine surgery can be fraught with challenges at various stages. Mal-occluded teeth can impede transcranial motor evoked potential (TcMEP) monitoring. Prone positioning may further compromise existing myelopathy. Tibial somatosensory evoked potentials (SSEP) may be absent at baseline due to the myelopathy. Certain total intravenous anesthesia (TIVA) can enhance the SSEPs. Here, a case is reported with such challenges that required customizing the IONM along with systematic interpretation of IONM signals, leading to a good outcome.

Case presentation: A 73-year-old male with severe cervical myelopathy underwent C3-7 decompression with fixation under IONM. He had a deep bite, which was covered with 3 soft bite blocks made of gauze placed between the molars and incisors. Preposition baseline bilateral Median SSEPs were well elicited, but bilateral baseline Tibial SSEPs were absent. Hence, Ulnar SSEPs were recorded to increase the yield of SSEP monitoring. Postposition TcMEPs were absent from the foot muscles and attenuated significantly in the other muscles. Reducing the neck extension restored the signals. The patient was given bolus etomidate prior to closure. A significant augmentation of SSEP amplitudes was noted. Etomidate can augment the amplitude of cortical SSEP recordings. The surgery was completed uneventfully, and the patient did not have any postoperative neurologic deficits.

Conclusion: This case highlights the importance of tailoring IONM methodology, like creating the soft bite block, so that TcMEP could be monitored, employing Ulnar SSEPs when Tibial SSEPs were unrecordable because it was below the level of the lesion, prompt recognition and correction of position-related signal alerts, and awareness of specific effects of anesthetic agents to avoid misinterpretation

INTRODUCTION

Intraoperative neuromonitoring (IONM) has firmly established itself in the armamentarium of spine surgeries, as it provides a crucial safety net in preventing neurological injuries. Among the various techniques available, somatosensory evoked potential (SSEP), transcranial motor evoked potentials (TcMEP), and electromyography (EMG) are the most commonly used modalities [1]. Notably, in 2012, the American Academy of Neurology, together with the American Clinical Neurophysiology Society, produced an evidence-based guideline update for the use of IONM. Their findings indicated that changes in evoked potentials (EPs) during surgery were significantly associated with adverse outcomes such as paraparesis, paraplegia, and quadriplegia, while conversely, no such outcomes were observed in patients without EP changes [2]. However, before alerting the surgeon about a significant signal change, systematic troubleshooting should always include a technical check for impedances, global changes due to anesthesia, hemodynamics, and the surgical context of the alert. In craniovertebral and cervical spine surgeries, prone positioning can induce dramatic compromise and signal changes [3,4]. TcMEPs may cause inadvertent movement, among which bite injuries are the most frequent. In rare cases, even mandibular fractures have been reported [5]. In a patient with misaligned or loose teeth, excluding TcMEP and relying solely on SSEPs would compromise the quality and effectiveness of IONM. To mitigate these risks, soft bite blocks made from rolled gauze, cotton rolls, or silicone-based materials are used, but may warrant modifications to adapt to a particular case. Although IONM is typically employed to alert the surgeon about impending neurological injury, emerging evidence suggests that improvements in IONM signals may also prognosticate a favorable postoperative neurological outcome [6]. Nevertheless, one has to remain cognizant of anesthesia-induced augmentation of EP amplitude, which is contrary to the usual effects observed with most TIVA, thus necessitating careful interpretation of monitoring data [7]. This case report discusses challenges in cervical spine surgery and shows how IONM strategies need to be tailored in a timely fashion to ensure patient safety and optimal outcomes.

CASE PRESENTATION

A 72-year-old male presented with 1 1-year history of progressive worsening of gait. His past medical history was significant for ischemic heart disease (IHD) with an ejection fraction (EF) of 20 %. His MRI showed severe cervical canal stenosis and compressive myelomalacia C3-4 to C6-7 level (Figure 1).

He was planned for C3-6 laminectomy and C3-7 fusion. Examination showed normal vital parameters, spastic gait with brisk lower limb reflexes, and mute plantar reflexes. He was taken up for surgery under IONM. Transcranial motor-evoked potential (TcMEP), somatosensory-evoked potential (SSEP), and electromyography (EMG) were planned for intraoperative neuromonitoring using the NIM-Eclipse system, Medtronic (USA).

Figure 1. Sagittal T2-weighted image revealing degenerative changes with multiple disc bulges causing severe cervical canal stenosis. Resultant T2 hyperintense signal in the cervical cord extending from C3-4 to C6-7-disc level is most likely to represent changes of compressive myelomalacia.

Balanced anesthesia (TIVA) was used in the form of intravenous infusion of remifentanil along with sevoflurane with MAC 0.3. Bolus Etomidate was used in the latter part of surgery as and when needed to supplement remifentanil. Neuromuscular block was given only for intubation. Usually, two bite blocks made of rolled gauze are placed between the molars to protect the endotracheal tube and prevent tongue bite. However, because the patient had a deep bite, a third bite block made of rolled gauze was placed between the molars, making it a 3 3-piece bite block (Figure 2).

Figure 2. Soft roller gauze is placed between the incisors to protect them from complications of deep bites.

Corkscrew electrodes were placed at M1, M2, M3, and M4 for linked quadripolar stimulation using a double train of 8 pulses, 75 µs duration each, 250 Hz at 140 volts after ascertaining the threshold. Recording was done using a paired needle electrode, placed bilaterally in the trapezius (control), deltoid, biceps, extensor digitorum communis, abductor pollicis brevis, tibialis anterior, and abductor hallucis. Bilateral Median SSEP (control) and bilateral Tibial SSEPs (test) were recorded. Stimulation was done using paired needle electrodes (up to 30 mA, 200 µs, 4.7 Hz). Recording was done using corkscrew electrodes placed at Fz, Cz, C3', C4' (30–300 Hz bandpass, 300 averages). Since baseline Tibial SSEPs were absent, Ulnar SSEPs were added to the IONM paradigm to provide for test modality below the level of the lesion (Figure 3).

Initial baselines were taken in the supine position. Thereafter, the patient was placed in the prone position on the surgical table with neck flexion. Careful attention was given to the appropriate positioning of limbs and padding. Postpositional TcMEP showed loss of responses from both Abductor Hallucis and significant attenuation of the rest. SSEPs remained unchanged. Quick algorithmic troubleshooting involved a technical and impedance check for dislodged electrodes. No significant change was noted in anesthesia and blood pressure. Hence, a position-related alert was deduced. Serially, the extent of neck flexion was reduced. The TcMEPs returned when the neck was in neutral position (Figure 4).

Figure 3. Illustration of baseline bilateral median, Tibial and Ulnar SSEP.

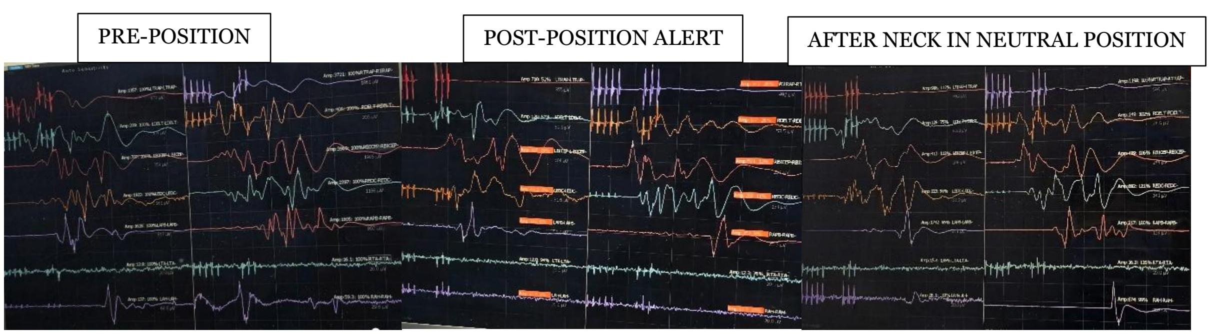

Figure 4. TcMEP-left and right panel. Top to bottom- trapezius, deltoid, biceps, extensor digitorum communis, abductor pollicis brevis, tibialis anterior, abductor hallucis. Sweep speed- 100 ms/div.

Thereafter, the surgery progressed uneventfully. During the final stage of instrumentation, bolus etomidate was used. Bilateral Median and Ulnar SSEP amplitude augmentation was noted to the tune of 450- 900 % (left Median- baseline 0.44 uV to final 3.4 uV, right Median baseline 0.34 uV to final 3.3 uV, left Ulnar baseline 0.35 uV to final 3.5 uV, right Ulnar baseline 0.49 uV to final 2.6 uV) (Figure 5).

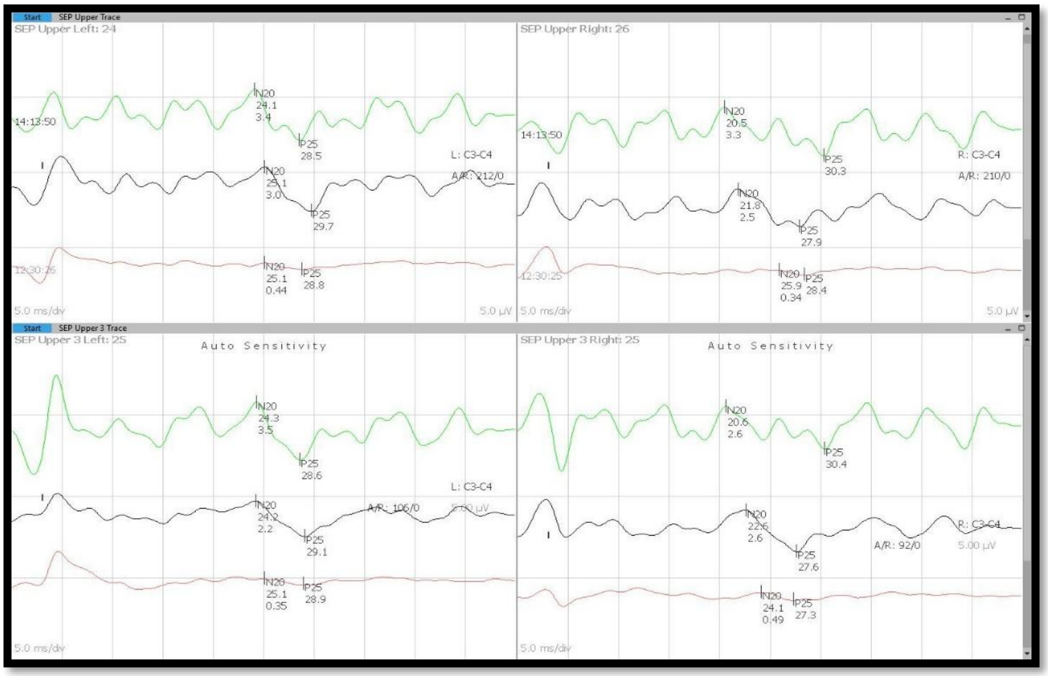

Figure 5. Illustration of bilateral median and ulnar SSEP at end of surgery- red trace-baseline, black trace- current average, green trace- previous average.

Regular documentation of anesthesia regimen revealed the use of bolus Etomidate. It was the reason for the augmentation rather than informing the surgeon about the false improvement of SSEP amplitudes.

CONCLUSION

IONM provides real-time feedback to the surgeon about impending neurological injury within a time window where it is reversible. TcMEP can cause complications like dislodgement of loose teeth, mandibular fracture, lip and tongue lacerations, which were a serious possibility in this case given the deep bite [5]. Excluding TcMEP from the neuromonitoring paradigm would have greatly compromised the quality of IONM. In such a situation, using a third soft roller gauze padding between the incisors and checking its effectiveness during TcMEP when the patient was supine greatly facilitated the success of IONM.

Since TcMEPs are tested intermittently, SSEPs should be included as a part of multimodality IONM even though it is relayed along the dorsal columns. No universally standardized SSEP monitoring approach exists because the best way would be to tailor it according to the level of the lesion by having a test SSEP and a control SSEP. Upper and lower limb SSEPs are advised for cervical spinal cord monitoring. Lower SSEPs test modality for thoracic spinal cord monitoring and upper limb SSEP are controls [8.9]. Hence, it seems prudent to monitor all four limbs for both levels. Ulnar SSEPs are recommended when surgery risks C7-C8 cord injury that might be missed by median SEPs. In this case, baseline Tibial SSEPs were absent most probably due to the myelopathy. The presence of adequate twitch from both Abductor Hallucis on free-running EMG rules out peripheral pathology. Optimal impedances ruled out technical factors. Hence, Ulnar SSEPs were included to provide an additional layer of test modality.

Since prone positioning can cause neurological compromise, the first step here was to secure good supine baselines by way of TcMEP and Median, Ulnar SSEPs. Rapid troubleshooting is imperative. Thus, a change in EPs related to prone positioning was identified when other confounding variables such as technical, hemodynamics, and anesthesia considerations were ruled out and corrective measures were taken [10].

Some studies have postulated a positive correlation between improved IONM signals and clinical outcome [11-15]. It is also known that certain anesthetic agents, such as Ketamine, can enhance SSEP and MEP responses while Etomidate can augment the amplitude of cortical SSEP recordings without affecting the peripheral evoked potentials or subcortical responses [7]. Anesthesia drugs, dosages, and vitals were documented every 30 minutes as per IONM protocols. This helps to correlate EP changes, as in this case, where bolus Etomidate was used in the later stages. It led to a huge amplification of SSEP, but awareness of the use of bolus Etomidate prevented undue comment on possible clinical improvement.

Multimodal intraoperative monitoring can be more effective by tailoring protocols, paying attention to safety during crucial stages, and anesthesia protocols. This case report underscores the importance of individualized intraoperative neuromonitoring strategies in addressing complex challenges such as absent baseline signals, positional alerts, and anesthetic-induced signal changes, which are often encountered in high-risk cervical spine surgeries. By showcasing how proactive adaptations and systematic troubleshooting can ensure accurate interpretation and patient safety, this case report highlights a potential framework for refining IONM protocols in diverse surgical settings.

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