Case Report
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Spinal Cord Stimulator Procedure with Intraoperative Neuromonitoring Protocol

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Abstract

Spinal Cord Simulators (SCS) are routinely placed in cases medically refractory to pain. Paddle leads are placed under general anesthesia using fluoroscopy and Intraoperative Neuromonitoring (IONM) for midline placement with adequate coverage. After a successful trial of the SCS device with the patient, the implant of paddle leads is ordered for permanent placement in the epidural place under general anesthesia. The leads are implanted based on area of pain, but typically, not proximal to C3-4 levels of the spine. In the case we discuss, our patient was experiencing pain in the shoulders and arms, but additionally had occasional headaches in the occipital region. Therefore, the SCS device was trialed to extend up to the C3-4 levels. Because the patient had a partially successful trail with >50% reduction in pain but remaining headaches, the procedure planned was for placement of permanent paddle leads extending up to the C1-2 levels with Intraoperative Neuromonitoring (IONM).

Keywords: Spinal cord stimulator • SCS • IONM • Intraoperative neuromonitoring • Spine • Neurology • Potentials • Cervical • Thoracic • Lumbar • SSEP • EMG • MEP • Evoked potentials

Introduction

Intraoperative Neuromonitoring using SSEPs (Somatosensory Evoked Potentials), MEPs (Motor Evoked Potentials) and EMG (Electromyography) has been significant in helping identify and prevent neurological injury [1]. Though SSEPs and EMG have been shown to be significant in these procedures over the years, as shown in this case, MEPs have also proven to play a significant role in identifying and preventing permanent neurological damage.

With this case presentation, we hope to review how IONM can be helpful in preventing nerve injury and identifying midline placement of the SCS leads [1]. Reviewing the case, we will see how IONM was crucial in alerting the surgeon and how MEP was helpful in identifying and preventing permanent neurological injury to the patient [2].

There were significant warning events in both SSEP and MEP responses during the procedure. The warning events manifested in SSEPs almost at the same time as they did in MEPs. The physiologic midline was unable to be corroborated by SSEPs or EMG due to these events. The procedure was aborted after the leads were placed. Once the patient was awake, the patient deficits manifested were consistent with the warning events noted. The patient had to be brought back to the Operating Room (OR) for an emergent removal of the paddle leads which led to a return of function.

Based on these findings The IONM protocol for a Spinal cord stimulator implant should include:

SSEP responses from- Ulnar/ Posterior tibial nerve stimulation if placement location is cervical, then median nerve and Posterior tibial nerve stimulation.

EMG recording from muscles pertaining to level of insertion and a level above and below. Usually since leads are placed in cervical and lower thoracic regions of the spine, muscles to monitor would include Deltoid, biceps, triceps, hands. Lower extremities- Quadriceps, Anterior tibialis, gastrocnemius and foot. MEP would include the same muscles used for EMG monitoring [2].

For a SCS placement procedure, in addition to the above protocol, testing the leads by increasing frequency from 1–60 Hz at 1 V increments to record the lateralization of CMAPs (compound muscle action potentials) seen in sEMG activity and look for reduction in corresponding side SSEP amplitudes due to collision, guides the surgeon in adjusting placement of the leads to provide adequate coverage, which we were unable to be perform in this case, due to the adverse events during the procedure.

Case Presentation

This was a slightly heavyset 45-year-old male with recurrent neck and shoulder pain over a period of 6 months. The pain is brought on by exertion and change in neck positions. He has said it was initially relieved temporarily by rest and OTC (Over The Counter) pain medication but has since remained constant over the past few months. He has tried prescribed pain medications and injections with no significant reduction in pain. He has undergone a trial for SCS implant with temporary leads placed up to C3-C4 levels 2 weeks ago. According to the patient, he had experienced >50% reduction in pain but has had occasional headaches and some neck pain intermittently. Based on this it was considered a partially successful trial [3] with the plan to place permanent SCS leads extending up to C1-2 levels under general anesthesia utilising fluoroscopy and intraoperative neuromonitoring. Intraoperative neuromonitoring was to be an integral part of the procedure, both for localisation of the leads and also help to prevent any neurological insult. Anesthesia regimen discussed was TIVA with propofol, fentanyl, succinylcholine for intubation, no muscle relaxant during procedure and bite block to prevent tongue lacerations [4,5].

Procedure and Outcomes

The patient was intubated and positioned prone for the procedure. Upon the surgeon's request, the protocol utilised for neurophysiological monitoring was transcranial Motor Evoked Potentials (MEPs), Somatosensory-Evoked Potentials (SSEPs) and Spontaneous EMG utilising the same muscles as used for MEPs. SSEPs from median nerve/posterior tibial nerve, MEPs from upper/lower extremities and spontaneous EMG were recorded throughout the procedure.

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SSEPs were recorded from stimulation of the peripheral nerves at intensities of 25mA for MN and 40mA for PTN, RR of 1.41, pulse width of 200microsec and responses were averaged over 200 trials. In accordance with 10-20 international classification, electrodes were placed at Fz, Cz, C3', C4' and mastoid for subcortical responses. Montages used were C3'-C4', C3'-Fz for left and C4'-C3', C4'-Fz for right with focus on cortical responses. Bipolar needle electrodes were placed in Trapezius, Deltoid, Biceps-Triceps, APB-ADM, Anterior tibialis and gastrocnemius muscles. MEP and EMG recordings were obtained from these muscles. MEP responses were recorded at 350-450V intensity with ISI 1.5-2, PW 75microsec, Train 7-9 pulses. Stimulation leads were placed at C3 and C4. Baselines were obtained prior to incision with good morphology and similar amplitudes bilaterally for SSEPs, MEPs present in all muscles and no spontaneous EMG activity.

During the procedure, the trial leads were removed, and permanent paddle leads were being placed in the epidural space extending up to C1 level using fluoroscopy as a guide for proper anatomical midline placement. SSEP, MEP and EMG were being monitored continually during the procedure with no significant changes. As the leads reached the C3 level, there was a significant drop in SSEP amplitudes (Figure 1) and MEP responses were absent bilaterally (Figure 2). EMG showed intermittent spontaneous discharges not pertaining to any one muscle. Surgeon was immediately alerted of the changes. An increase in BP (Blood Pressure) was requested and MAPs (Mean Arterial Pressure) were maintained over 90. There was no other change in the anesthetic regimen. Troubleshooting and checking the position of the limbs was performed. None of the measures taken had any change on the SSEP and MEP responses. SSEPs showed greater than 80% decline in amplitudes at this time with MEPs remaining continually absent. The leads were placed up to C2 level and the procedure was aborted without testing the placement of leads. The patient was moved to post op still intubated. Upon extubating, the patient had marked reduction in strength in both upper and lower extremity with difficulty in breathing. The patient was brought back to the OR emergently for removal of the leads. SSEP, MEP and EMG were recorded utilising same parameters and muscles as for the previous procedure. Anesthesia regimen also remained the same. SSEPs were markedly reduced, and MEPs were absent with no spontaneous EMG activity at baseline. The paddle leads were removed; the MAPs were increased and maintained over 90. SSEPs and

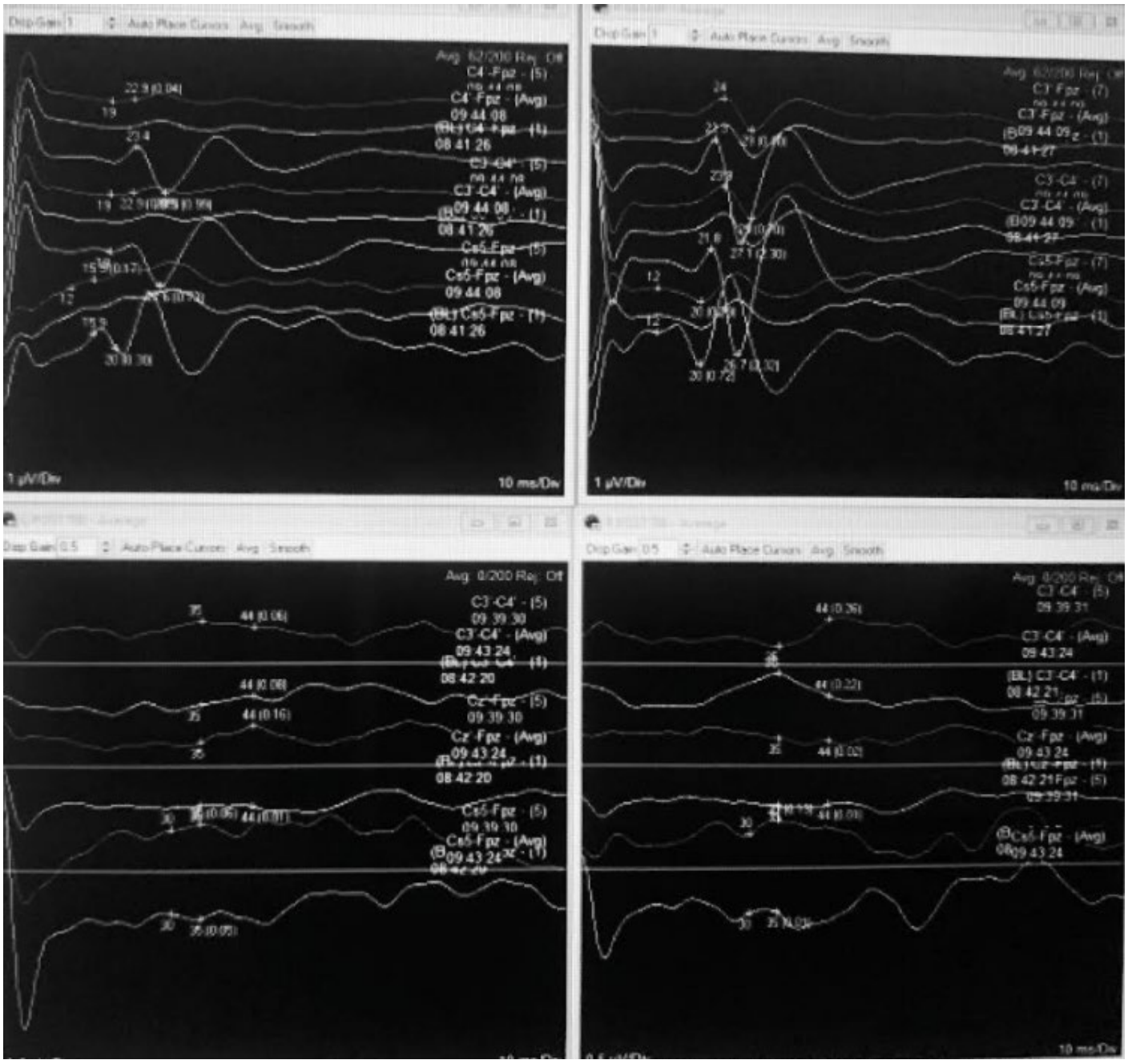

Figure 1. Reduction in SSEP responses.

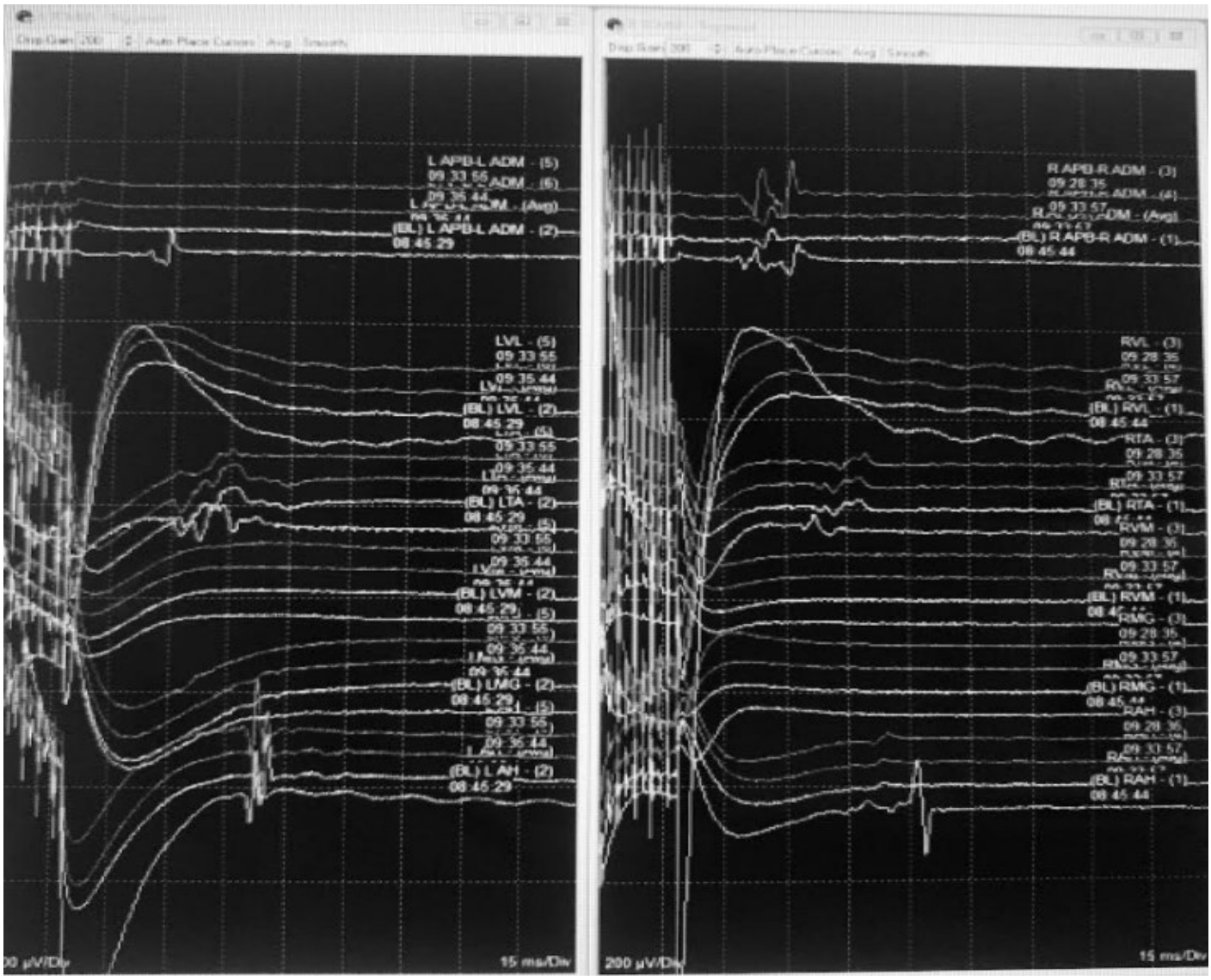

Figure 2. Loss of MEP responses.

MEPs were continually recorded during this time. We began to see a return of SSEPs and MEPs at this time. Over a period of 15 minutes, with continuous monitoring, SSEPs and MEPs were present with reproducible responses at steady amplitude. The incisions were closed, and surgery completed. The patient was extubated in the OR and movement was recorded in all 4 extremities. Patient was shifted to ICU with MAPs to be maintained over 90.

Results and Discussion

There were significant warning events in both SSEP and MEP responses during the procedure. The warning events manifested in SSEPs almost at the same time as they did in MEPs. The physiologic midline was unable to be corroborated by SSEPs or EMG due to these events. The procedure was aborted after the leads were placed. Once the patient was awake, the patient deficits manifested were consistent with the warning events noted. The patient had to be brought back to the OR for an emergent removal of the paddle leads which led to a return of function.

Conclusion

In conclusion, it was theorised that the paddle leads being extended to C1-2 placed pressure on the spinal cord in a position that was not well tolerated resulting in transient neurological injury. Their positioning was unable to be corroborated due to the significant changes in SSEPs and MEPs. Testing the leads by increasing frequency from 1-60HZ at 1 V increments, the lateralization of CMAPs (Compound Muscle Action Potentials) seen in EMG activity, reduction in corresponding side SSEP amplitudes due to collision, would have helped in adjusting placement of the leads to provide adequate coverage, which we were unable to perform due to the adverse events during the procedure. As seen in this case, MEPs can be highly beneficial along with SSEPs in alerting and preventing neurological injury in higher cervical procedures.

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