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Case report

Spinal lumbar multimodal neurophysiological monitoring in a patient with deep brain Stimulator: A case report

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ABSTRACT

Intraoperative neurophysiological monitoring (IONM) is a highly valuable tool in spinal surgery. It allows for real-time evaluation of nervous system function and alerts the surgeon to any warning signs. Among the various techniques used are motor evoked potentials (MEPs) through transcranial electrical stimulation, which involve applying an electrical stimulus to the scalp in the primary motor cortex region and recording it in the corresponding muscles of the corticospinal tract. There are relative contraindications for this technique, such as in patients who have an implantable device. There is no consensus on how to perform this technique in patients with a deep brain stimulator.

We present the case of a 61-year-old patient with Parkinson's disease and a deep brain stimulator (DBS), and who underwent spinal surgery for lumbar discopathy. IONM was performed during the procedure using MEPs, necessitating the deactivation of the DBS to protect its function. Upon completion of the surgical procedure, the device was reactivated, confirming its proper function. We demonstrate that this technique can be safe for these patients, weighing the potential risks and benefits. However, it will be necessary to develop specific guidelines for performing these techniques in the future.

1. Introduction

Intraoperative neurophysiological monitoring (IONM) represents an indispensable tool employed in surgical procedures that affect the nervous system. In the context of spinal surgery, it plays a crucial role by facilitating the early detection of potential inadvertent nervous system injuries, thereby allowing for the implementation of preventive measures to avoid their progression. Additionally, it provides precise information for the exact localization of relevant anatomical structures, significantly contributing to the prevention of iatrogenic damage. (Wong et al., 2022) The different techniques that can be used for IONM in spinal surgery include somato-sensory evoked potentials (SSEP), transcranial electrical motor evoked potentials (MEPs), free-running electromyography (fEMG), triggered electromyography (tEMG), and the D-wave. (Agarwal et al., 2022; Wong et al., 2022) When multimodal monitoring is used, which consists of combining these techniques, the sensitivity and specificity approach 100 %. (Lall et al., 2012) However, there are safety concerns about to use of transcranial electrical MEPs in patients with implantable devices during neurosurgeries (Journée and Shils, 2022; Revilla-Pacheco et al., 2022; Yellin et al., 2016), and limited information is available to guide the procedure (Srisooksai et al., 2021). We present a patient with spinal lumbar stenosis and Parkinsońs disease with a Deep Brain Stimulator who underwent a spinal surgery with multimodal intraoperative neurophysiological monitoring.

2. Case presentation

We present a 61-year-old right-handed male patient with a long-lasting history of Parkinson's disease, which was treated pharmacologically with levodopa/carbidopa and with the placement of a deep brain

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stimulator (DBS; ACTIVA™ RC Recharger Model WR9200, Medtronic, Minneapolis, MN, USA) and connected to an MRI-conditional impulse generator implanted beneath the left clavicle, four months prior to the spinal surgical procedure. [Fig. 1].

Two months ago, the patient began experiencing lumbar pain radiating to the pelvic limbs, predominantly on the left side. During a ride on a jet ski, the patient developed sudden claudication in both pelvic limbs, accompanied by weakness and inability to move them, as well as fecal and urinary incontinence. He was diagnosed with lumbar canal stenosis secondary to discopathy at the L4-L5 level, in addition to facet and ligamentous hypertrophy at the L3-L4 level. A spinal decompression surgery guided by multimodal IONM was scheduled using general anesthesia with intravenous propofol and fentanyl. The patient, his parents, the anesthesiologist, and the implanting neurosurgeon discussed the dual objectives of monitoring motor function during the spinal fusion and maintaining the integrity of the DBS system. A preoperative written inform consent of the patient was obtained for the procedures. The decision to use IONM during this neurosurgery was driven by patient-specific risks (long-history of severe Parkinson disease and recent fecal and urinary incontinence) and institutional protocols aimed at maximizing safety.

During anesthesia induction, the DBS was turned off, leading at 1 min to the emergence of bilateral resting and action tremors predominantly in the upper limbs, as well as a generalized rigid posture, which resolved upon reaching a steady state of anesthetic dosage additional to the rocuronium induction doses only used in this step. The IONM procedure was conducted using a Cascade IOMAX Cadwell system (Kennewick, WA, USA), employing fEMG, MEPs and SSEPs. The latter involved recording cortical potentials using corkscrew electrodes placed over the sites of sensory cortex projection at C3′, C4′, Cz', and Fpz, with bilateral posterior tibial nerve stimulation at 25 mA. Transcranial electrical MEPs were recorded from the vastus lateralis, anterior tibialis, medial gastrocnemius, and abductor hallucis muscles bilaterally, with monitoring of the abductor digiti minimi muscles for control. Stimulation was performed using corkscrew electrodes placed in the motor cortex projection area (C3-C4; 28 and 36 cm from DBS generator, respectively and, both 5 cm from the DBS leads); with an intensity of 440 Volts in a double train mode of 3–6 pulses at 50-us pulse width for facilitation of the MEPs recordings. [Fig. 2].

At the baseline, SSEPs showed a normal latency and amplitude for both peripheral and central responses. Otherwise, baseline MEPs recordings showed normal motor responses from both tibialis anterior and extensor digitorum longus muscles. However, no assessable responses were observed bilaterally for the vastus lateralis, medial gastrocnemius, and abductor hallucis muscles. Following lumbar decompression, responses were observed in all recorded muscles, the procedure occurred

Fig. 1. Wireless patient programmer for the DBS. This device allows changing parameters and turning the DBS on and off.

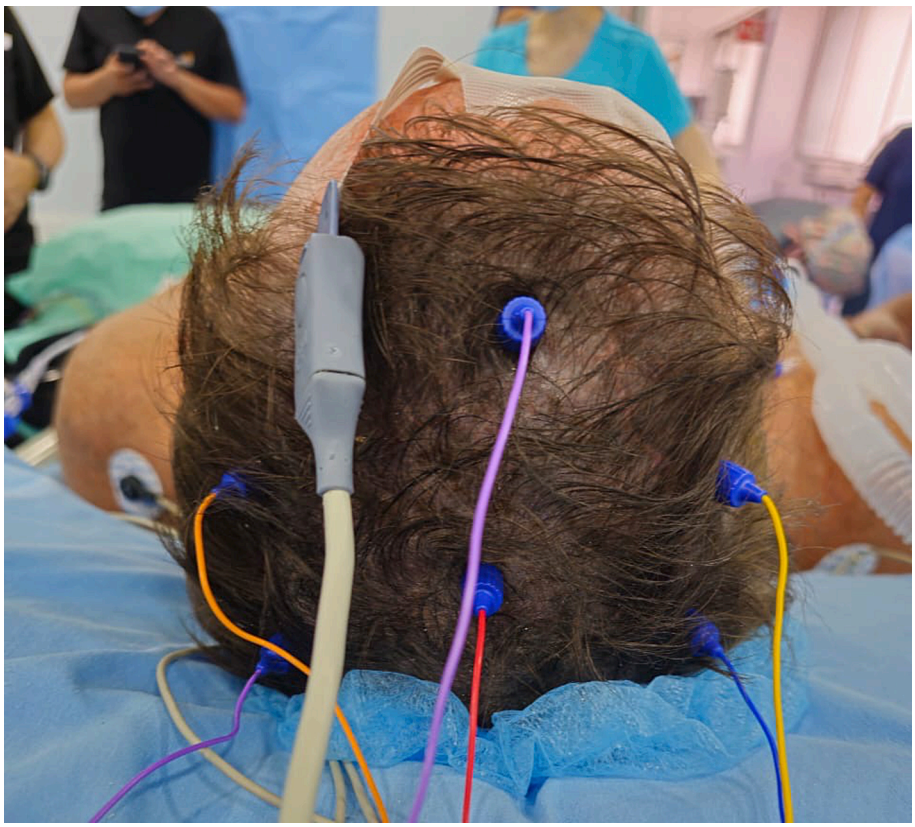

Fig. 2. Placement of corkscrew electrodes used for intraoperative neurophysiological monitoring. Electrodes are observed at Cz', C3′, C4′, and Fz for the somatosensory evoked potentials technique, and at C3 and C4 for motor evoked potentials.

90 min after the administration of rocuronium, and the TOF (Train-of-Four) showed full recovery of muscle relaxation at this stage. However, the effects of anesthetics and rocuronium used during the baseline MEPs should not be disregarded SSEPs were monitored throughout and remained unchanged as well. **[**Figs. 3-4**]** .

The patient underwent a laminectomy and foraminotomy at levels L3-L4 and L4-L5. For both procedures, the patient was positioned prone on the operating table, and a left paramedian incision was made over the affected vertebrae at levels L3-L4 and L4-L5. Dissection was carried out through the tissue layers until reaching the paravertebral fascia, after which a tubular retractor was inserted, and the lamina and articular facet were identified. A laminectomy was performed with a high-speed drill, the ligamentum flavum was removed, the nerve root was retracted, and a microdiscectomy was performed. Contralateral decompression was achieved successfully. Additionally, no adverse events occurred with the anesthesia.

In the post-operative period, the patient was awake without any new neurological deficits and relieved neurological spinal symptoms; and the DBS was turned back on with similar pre-operative parameters showing a normal function with returning of the control of symptoms of Parkinsońs disease and was discharged at 48 h at home.

3. Discussion

We present this patient with Parkinsońs disease using a DBS implanted bilaterally in the basal ganglia, and lumbar spinal stenosis who underwent spinal surgical decompression guided by multimodal IONM. The objective of highlighting the potential safety of using transcranial electrical MEPs in patients with DBS.

The diagnosis of lumbar canal stenosis has an estimated prevalence of 9 % in the general population and reaches 47 % in individuals over 60 years of age. Surgical intervention to address this problem encompasses a wide range of techniques; however, despite the high success rates, up to 15 % of patients experience postoperative dissatisfaction. (Fisher et al., 1976) Decompression surgery is recommended for patients whose symptoms persist despite pharmacological treatment, with the possibility of using spinal instrumentation in cases of degenerative etiology. (Matz et al., 2016).

Multimodality IONM using transcranial electrical MEPs, SSEPs, fEMG, tEMG without or D waves is recommended during spinal surgeries to prevent neurological permanent damage. (Buhl et al., 2021; Costa et al., 2007) In particular, MEPs can be performed by applying a transcranial electrical stimulus through the placement of electrodes over the area of the primary motor cortex, allowing us to evaluate the integrity of the corticospinal tract. (Buhl et al., 2021) To achieve depolarization of the pyramidal cells at the cortical level, it is necessary to apply an electrical discharge with specific characteristics, such as a multipulse technique, and to adjust the intensity according to the patient's degree of disease. If the intensity is too high, certain complications related to the electrical stimulus may arise. (Costa et al., 2007). During MEPs monitoring, oral injuries, such as lacerations of the tongue, lips, or fractures of the jaw or teeth, have been described due to the contraction of the masticatory muscles. Additionally, there may be hair loss in areas where needle electrodes are placed on the scalp. (MacDonald, 2002; Yoshida et al., 1976) Although rare, other serious complications, such as epileptic seizures, cardiac arrhythmias, or asystole, have been reported. (Revilla-Pacheco et al., 2022).

Contraindications for MEPs include implantable devices such as pacemakers, cardioverter-defibrillators, and neural stimulators. It is recommended that if the function of these devices is not necessary during monitoring, they should be turned off and the output current set to zero. Although the evidence is limited regarding transcranial electrical stimulation in patients with these devices, recommendations have been made to place the stimulation electrodes as far as possible from the

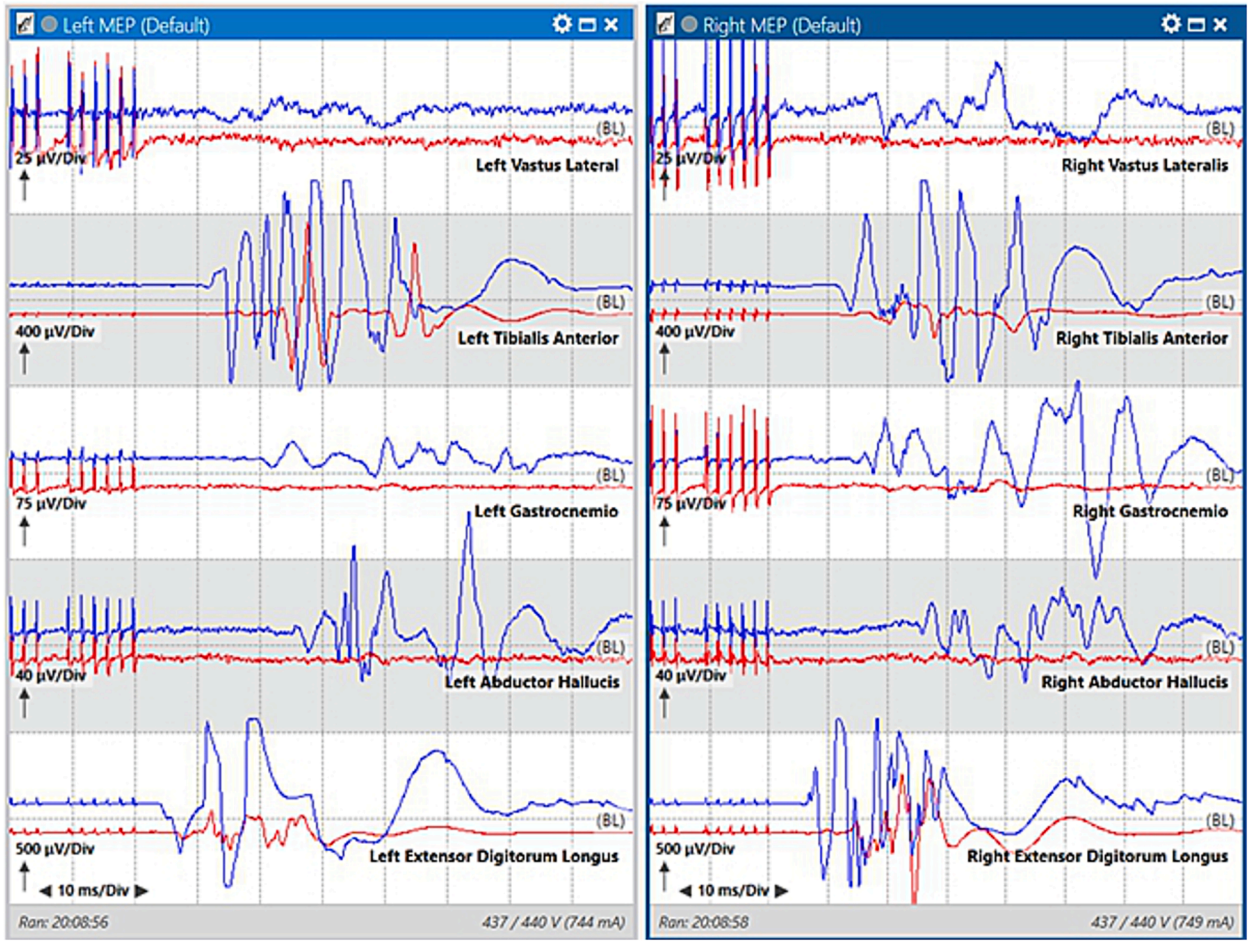

Fig. 3. Transcranial electrical Motor Evoked Potentials (MEPte). The MEPtes were obtained by stimulating the motor cortex bilaterally and recording in the vastus lateralis, tibialis anterior, gastrocnemius, abductor hallucis, and extensor digitorum longus muscles. Baseline recordings were performed prior to the intervention (red trace), and subsequently, the response was recorded after the surgery (blue trace). A significant bilateral increase in amplitude was observed in all the indicated muscles. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

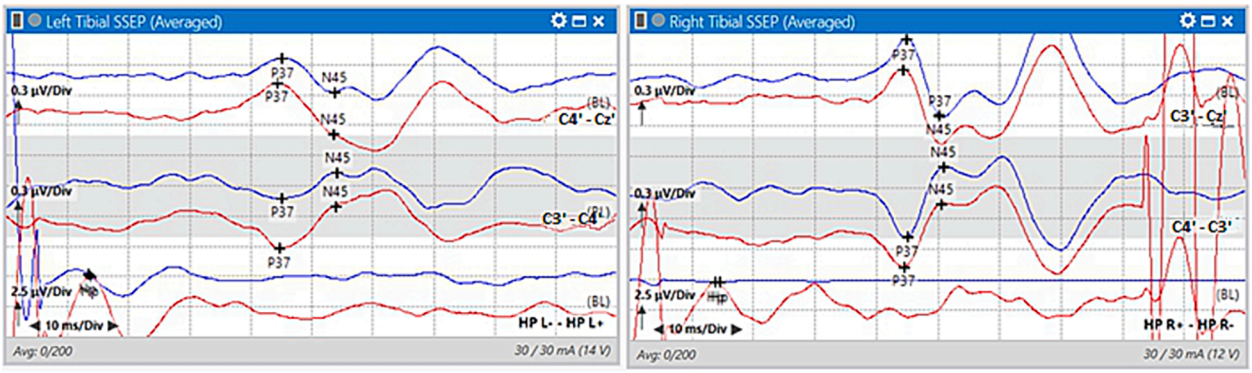

Fig. 4. Lower Limb Somatosensory Evoked Potentials (SSEP). The SSEP were performed with stimulation of the left and right posterior tibial nerves. The recordings were made with electrodes placed at Cz', C3′, and C4′, as well as the popliteal fossa. The baseline recording (red trace) and the recording taken at the end of the surgery (blue trace) are shown. Both amplitude and latencies remained unchanged. The potential recording at the right popliteal fossa was not obtained after the surgical decompression due to electrode disconnection. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

electrical components of the devices. (Journée and Shils, 2022) However, this recommendation is challenging to apply in our patient, who had an MRI-conditional impulse DBS generator implanted beneath the left clavicle, which remains immobile. Furthermore, the scalp C3/C4 electrodes allow for only 1–2 cm of adjustment, as per intraoperative clinical neurophysiology guidelines (Buhl et al., 2021; Costa et al., 2007; Fisher et al., 1976). Currently, a safe distance for these patients is unknown, and determining this is one of the aims of this case report for future clinical cases.

Yellin et al. and Abiola et al. reported two and one cases, respectively, in which IONM with MEPs was performed in patients with cochlear implants, without complications observed and the monitoring

conducted adequately. (Abiola et al., 2018; Yellin et al., 2016) In 2021, to our knowledge, the first case report of a patient with a DBS undergoing IONM with transcranial electrical MEPs was published. The patient, a 17-year-old, underwent scoliosis correction surgery and had a DBS due to generalized dystonia under intravenous anesthesia using propofol, methadone, and remifentanil. The device was turned off during the surgery, and the transcranial electrical stimulation parameters were kept to a minimum (230 and 250 V), with unchanged somatosensory or motor evoked responses. After the surgery, the DBS was turned back on, and no complications related to MEPs were observed, with the device continuing to function as expected. (Srisooksai et al., 2021) Our patient received a higher electrical current (440 V vs 230–250 V (Srisooksai et al., 2021) to elicit transcranial electrical MEPs and followed a similar protocol involving the intermittent turning off and on of DBS devices during surgery. While the risk of injury from lead heating is theoretically possible, no significant clinical evidence has been reported in the literature (Srisooksai et al., 2021), especially given the brief, intermittent nature of MEP stimulation (MacDonald, 2002). In our case, these risks were carefully assessed by a multidisciplinary team, and the DBS device was deactivated during MEPs to mitigate any potential hazards. The patient was fully informed of the risks, including the theoretical possibility of overheating, and provided informed consent. Postoperative testing confirmed the proper functioning of the DBS, with no adverse effects. We acknowledge that more research is needed to establish clear guidelines for performing MEP monitoring in patients with DBS. However, based on our findings, we recommend adopting a similar DBS management protocol for patients undergoing transcranial electrical MEPs to ensure safety.

Similarly to how this technique is performed in patients with pacemakers or cochlear implants, it is necessary to prioritize patient safety and also the functioning of the device after surgery. In our patient, the DBS was turned off, and the intensity of the electrical stimulation was kept at the minimum threshold to elicit responses in the muscles relevant to the surgery, thereby maintaining the utility of IONM.

While the complications described so far are minimal for patients with implanted devices, safety measures must be taken for the well-being of the patient. To prevent the electrodes used in MEPs from being placed near the site of the DBS electrodes, it was decided to use only the C3 and C4 points. The DBS had been placed four months prior, so tissue healing around the device had already been completed, thus maintaining the protection it provides.

Following the procedure, the functionality of any implanted device in the patient should be verified, as there is a possibility of it experiencing any alteration. In this case, malfunction does not imply serious complications for the patient's life and require surgical procedures to remove and re-implant the DBS devices to improve their quality of life.

Degenerative process of the lumbar spine more commonly develops in patients between the fourth and sixth decades of life (Zhang et al., 2023), coinciding with the onset age of neurodegenerative diseases such as Parkinson's disease. As we achieve a broader reach of advanced therapies, such as DBS, we will encounter more patients with implanted devices where MEPs will need to be utilized. For this reason, standardizing safety measures for these techniques is imperative.

4. Disclosure of conflicts of interest and ethical statements

The authors declare that they have no conflicts of interest in the conduct of this article and was conducted in accordance with the ethical standards. They declare that they have not received funding from any company or external organization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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