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# The Utility of Bispectral Index Monitoring in Management of Motor Evoked Potential Depression Occurring During Scoliosis Surgery under Total Intravenous Anesthesia: A Case Report

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author BGL performed anesthetic management of the patient, contributed to conception and design of this report, analysis and interpretation of data, drafting and proofreading the manuscript. Authors SGJ and ML performed administration of motor evoked potential, acquisition of data, and interpretation of data, and managed the literature searches. All authors read and approved the final manuscript.*

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***Case Report***

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## ABSTRACT

Motor evoked potential monitoring is becoming one of the gold standard monitoring performed to detect nerve injuries caused by surgical manipulation, especially motor deficits during spine surgeries, but there exist clinical situations that make its interpretation very challenging. Recently, a 19-year-old male who underwent scoliosis correction with total intravenous anesthesia using propofol and remifentanil showed overall motor evoked potential depression on all recording sites during surgery, only to show signal recovery after propofol infusion was stopped. We present the utility of bispectral index monitoring, a processed electroencephalogram monitor that measures the depth of anesthesia, in the situation when motor evoked potential depression occurs without any factors which affect motor evoked potential responses except anesthetic depth.

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*Keywords: Anesthetic depth; bispectral index; motor evoked potential; propofol; remifentanil; scoliosis surgery.*

## 1. INTRODUCTION

During spine surgeries, motor evoked potential (MEP) monitoring, somatosensory evoked potential (SSEP) monitoring, or a wake-up test is recommended to detect nerve injuries, and especially, this multimodal intraoperative neurophysiologic monitoring (IONM) of the spinal cord is recommended during scoliosis surgery which involves surgical correction of large scoliotic curves [1-3]. Of these monitoring tools, MEP monitoring is easier and safer to perform than a wake-up test, and has a better correlation with good motor outcome after surgery than SSEP monitoring in spinal surgery, as it directly measures the integrity of the descending motor pathways of the spinal cord [2,4-6]. However, as MEPs are more susceptible to the influence of anesthetics than SSEPs, MEP monitoring requires more restrictive anesthesia requirements and thus the choice of anesthetics is of paramount importance. Therefore, currently, a total intravenous anesthesia (TIVA) without muscle relaxants is generally chosen to facilitate and optimize IONM including MEPs [7,8].

There have been many researches supporting the reliability of intraoperative MEP monitoring in assessing the integrity of the spinal motor tract [9,10]. But it has been reported that the sensitivity/specificity of MEP monitoring are 100%/61% respectively [11]. Thus, when the interpretations suggest nerve injury, there is a chance of false positive caused by many factors that influence MEP responses.

Herein, we report a case of a patient whose MEP responses showed depression during scoliosis correction under TIVA using propofol and remifentanil and dramatically showed spontaneous recovery to baseline levels after propofol infusion was stopped. This case presents the utility of bispectral index (BIS; a processed electroencephalogram [EEG] value ranging from 0 [isoelectric] to 100 [awake] to identify the level of consciousness) monitoring, in determining the cause of MEP depression occurring during scoliosis surgery even though the surgery was done under TIVA.

## 2. CASE REPORT

A 19-year-old male (42kg, 143cm) with severe idiopathic scoliosis (Cobb's angle 80°) visited for scoliosis correction and posterior fusion of T3–L5. His preoperative evaluation results were all normal.

Glycopyrrolate 0.2 mg was intramuscularly injected as premedication 30 minutes before surgery. At the operation room, train-of-four (TOF) stimulator (S/5 Avance® Carestation Anesthesia monitor, Datex-Ohmeda, Helsinki, Finland) and bispectral index (BIS) monitor (BIS Vista™, Aspect Medical Systems, Newton, MA, USA) were applied.

For induction and maintenance of anesthesia, propofol and remifentanil were administered with a target-controlled infusion device (Orchestra® Base Primea, Fresenius Kabi, France). Infusion was started with the target effect-site concentration (CeT) of propofol 3.5 μg/mL and remifentanil 1.5 ng/mL, and after loss of consciousness, rocuronium 25 mg was administered and then tracheal intubation was done. Anesthesia was maintained with the CeT of propofol 3.0–6.0 μg/mL, remifentanil 1.5–2.5 ng/mL, and the BIS 40–60. An esophageal temperature probe was inserted for continuous body temperature monitoring. Transcranial electrical MEP (TCE-MEP) was applied throughout the operation. Two electrodes were inserted into the scalp for TCE-MEP stimulation, and the recording electrodes were inserted into the following four muscles, adductor pollicis brevis, abductor digiti quinti, tibialis anterior and abductor hallucis. The baseline values were set 2 hours after anesthesia induction when the TOF ratio were 90%. As a stimulation of 550 V was given using multi-pulse stimulation techniques, a normal baseline MEP waveform could be obtained (Fig. 1a). Thus the intensity of the impulse was decided, and stimulations were given intermittently before/during/after major surgical steps. Compared with baseline, it was considered to suggest noxious neural damage (positive result) if the MEP recordings showed more than 80% decrease in amplitude. No additional muscle relaxant was administered after anesthesia induction.

Total anesthetic duration was 9 hours. The vital signs were stable and the hemoglobin level was maintained between 12–14 g/dL, by aggressive transfusion carried out to compensate for the 6 L of blood loss during surgery. End-tidal carbon dioxide concentration, the arterial carbon dioxide

tension ($PaCO_2$), body temperature and TOF ratio were maintained between 30–35 mmHg, 35–40 mmHg, 35.5–36°C and 50–90%, respectively.

Seven hours after anesthesia induction, the MEP waveform obtained during pedicle screw fixation showed overall depression on nearly all recording sites (Fig. 1b). In this situation, propofol infusion was stopped to perform a wake-up test to confirm operative neural damage. Over approximately 10 minutes, the BIS gradually rose from 40 to around 75, and the amplitude of MEPs recovered its baseline spontaneously (Fig. 1c). Therefore, the wake-up test was not performed, and the surgery proceeded without modification of the surgical correction done at the manipulating site. Later on, the MEPs were depressed markedly again when the BIS decreased to 40 or below during the remaining procedures including pedicle screw fixation, rod insertion and derotation of scoliotic curvature. But they recovered their baseline after propofol infusion was stopped and the BIS increased to 70–75. The same phenomenon occurred 6 times in total (Fig. 2).

The rest of the operation was performed successfully without signs of nerve damage, changes in postoperative motor and sensory exam or intraoperative recall.

## 3. DISCUSSION

There are many intraoperative factors which influence MEP responses. Physiologic and anesthetic factors other than surgical factors are main contributors [12].

Hypotension, hypothermia, hypoxia and anemia are known as physiologic factors to influence MEP response [12-14]. In this case, blood pressure, body temperature, arterial oxygen tension, and hemoglobin were maintained within normal range as follows: 110/70–150/90 mmHg, 35.5–36°C, 230–250 mmHg, and 12–14 g/dL, respectively.

Anesthetic factors including the type, total dose of anesthetics, and the duration of anesthesia influence MEP responses [14]. Neuromuscular blockade by muscle relaxants strongly and directly inhibits MEPs. Thus in this patient, only single minimal dose was used for endotracheal intubation.

The anesthetic drugs used in the present case were propofol and remifentanil. Pelosi et al. [15] reported that continuous infusion of propofol is adequate for multi-pulse TCE-MEP monitoring. Opioids including remifentanil have little impact on MEPs [12]. In this case, the CeT for propofol was 3.0–6.0 μg/mL during surgery. The BIS was usually maintained between 40–60, but sometimes it would fall to 30–40, or increase to 60–70. Thus it could be deduced that when the BIS was low, the CeT of propofol was higher than necessary, and its high concentration would have inhibited MEP responses. Yamaguchi et al. [16] reported that when the BIS was below 40, it is hard to detect MEP responses, and concluded that the BIS range between 50–70 was ideal for MEP monitoring. Actually, in the present case, propofol was given at 160.5 μg/kg/min on average, which is larger than the recommended dose of 75-150 μg/kg/min combined with an opiate [12] and remifentanil was given at the low dose of 0.108 μg/kg/min on average. Therefore, propofol overdose could be a possible explanation for MEP depression events. We could have prevented the false positive MEP depression if we had kept their ranges more optimal by adjusting the infused dose of propofol on the basis of more cautious monitoring of BIS scores.

BIS values are changed not only by anesthetic concentration but also by surgical stimuli. Although opioid itself has little effect on EEG in the clinical concentration, it affects EEG by blocking the influence of surgical stimuli. BIS values can be dose-dependently changed by remifentanil as it can suppress the response to noxious stimuli [17]. It is known that a high dose of opioid is required to suppress the response to intense noxious stimuli accompanied with the correction of scoliosis. The CeT of remifentanil, 1.5–2.5 ng/ml used for analgesia in our case would be insufficient for this type of surgery. Furthermore, insufficient analgesia often increases the facial muscle activity. Contamination of electromyographic activity could increase BIS value regardless of the patient's hypnotic level [18]. We think that BIS value fluctuated because noxious input was not adequately managed by such fairly low concentration of remifentanil. Generally, with the concept of current balanced-anesthesia, what anesthesiologists should aim to manage is surgical stimuli. As propofol does not have analgesic effect, it is not rational to change the concentration of propofol during surgery. Once, the adequate CeT of propofol was determined by BIS monitor before the start of surgery, it should have been kept constant

throughout the surgery in principle. Then, the CeT of remifentanil should have been adjusted. If the patient had been managed with this strategy, we could have avoided high propofol concentration and thus prevent depression of MEP responses.

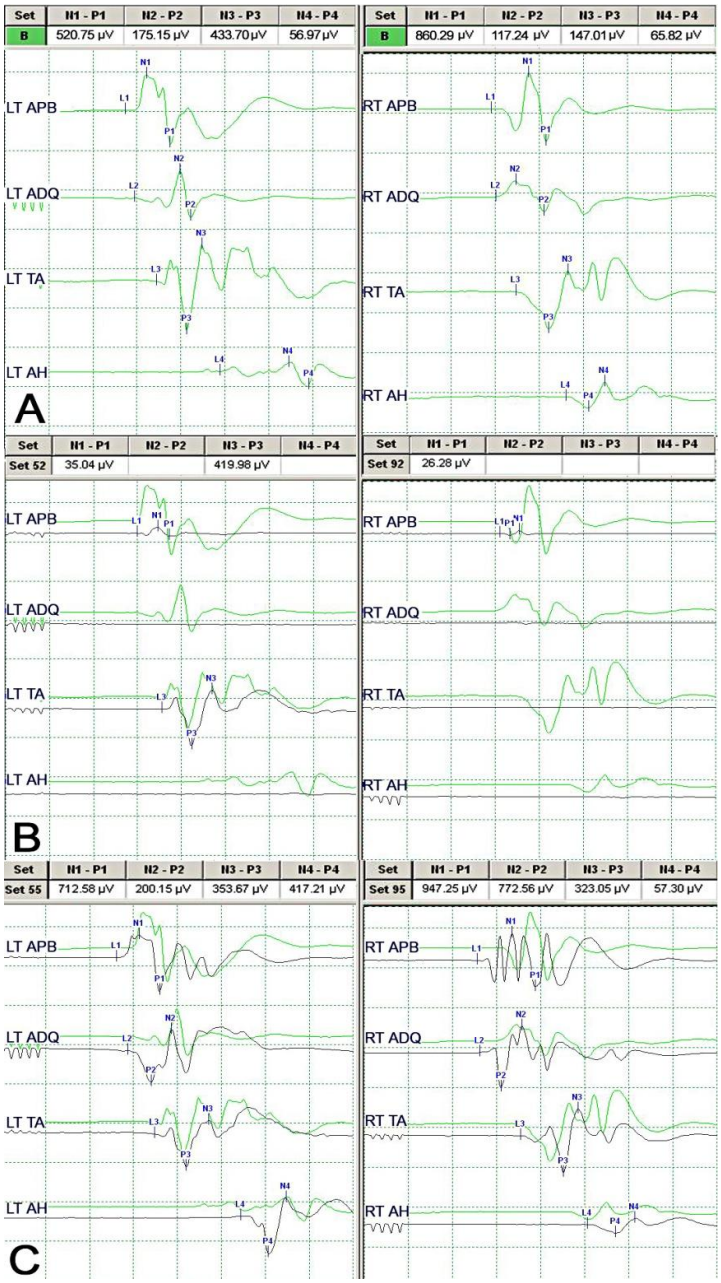


**Fig. 1. Baseline motor evoked potentials (MEPs) (a), marked depression of MEP responses occurring 7 hours after anesthesia induction (b), and restoration of the MEP responses after BIS increased (c). (a) Baseline MEPs (green lines). The intensity of transcranial electrical MEP is 550 V. (b) MEP signals (black lines) which were depressed markedly during total intravenous anesthesia (TIVA) 7 hours after induction. (c) MEP signals (black lines) which spontaneously recovered as bispectral index (BIS) became around 80 after TIVA was stopped. B: baseline. LT: left. RT: right. APB: adductor pollicis brevis. ADQ: abductor digiti quinti. TA: tibialis anterior. AH: abductor hallucis.**

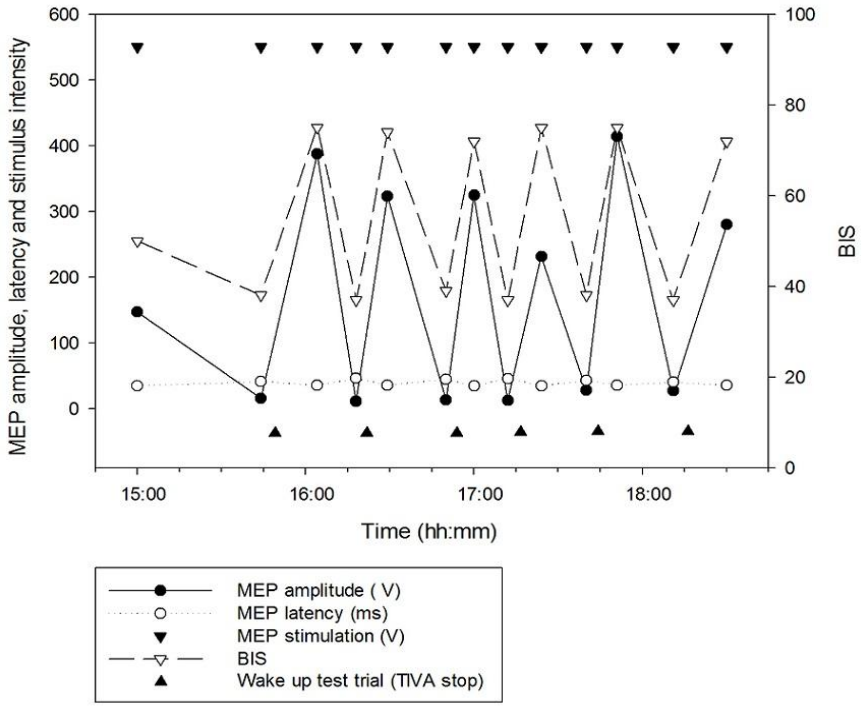


**Fig. 2. MEP amplitude, MEP latency and BIS changes before/after trials of the wake-up test at the time points in which the MEP amplitude was depressed markedly compared to that of baseline on right tibialis anterior**

Also, Lyon et al. [19] reported that regardless of the anesthetic regimen or the dose-dependent depressant effect, the longer the duration of anesthetics exposure measures, the weaker the response of MEP becomes. They named this phenomenon “anesthetic fade” and suggested that its recognition is essential when interpreting MEP changes to avoid false-positive findings. Our patient first showed low MEP signals 7 hours after anesthesia induction, so the increased duration of anesthesia could have contributed to the abnormality as well.

Taken together, the repetitive events of false positive MEP depression observed in this case could be attributed to the deeper than necessary hypnotic level demonstrated by low BIS of below 40, caused by prolonged infusion of high dose propofol and the insufficient analgesia due to low dose remifentanil infusion. Fortunately, we observed restoration of the MEP responses following recovery of level of consciousness using BIS monitoring after stopping anesthetic drugs, resulting in providing safe MEP stimulation within a level of sedation (BIS of 70–75) as well as avoiding a wake-up test.

## 4. CONCLUSION

To optimize patient safety and IONM while preventing nerve injuries during TIVA for spinal surgery, we suggest continuous evaluation of anesthetic depth by BIS monitor and that MEP stimulation should be performed under optimal BIS ranges. BIS monitor can help to find the optimal time and anesthesia level for the safe MEP stimulation and adequate MEP response. The addition of the BIS monitor to the current anesthesia practice for spinal surgery done under TIVA is novel and has a potential to greatly improve accuracy of current IONM while decreasing the need for wake-up tests.

## CONSENT

As per international standard or university standard, patient’s written consent has been collected and preserved by the authors.

## ETHICAL APPROVAL

It is not applicable.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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