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The Spine Journal ■■ (2015) ■■–■■

THE SPINE JOURNAL

Clinical Study

# Intraoperative motor evoked potential monitoring to patients with preoperative spinal deficits: judging its feasibility and analyzing the significance of rapid signal loss

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Received 27 May 2015; revised 19 August 2015; accepted 3 September 2015

**Abstract**

**BACKGROUND CONTEXT:** Transcranial motor evoked potential (MEP) monitoring has been widely adopted in spine surgery, but so far the useful monitoring data for the Patients with preoperative spinal deficits (PPSDs) are limited. Originally we thought that they seemed technically more difficult and less reliable in performing the MEP monitoring to PPSDs.

**PURPOSE:** Our objective was to study (1) the feasibility of MEP monitoring in PPSDs and the (2) the significance of rapid MEP loss.

**STUDY DESIGN/SETTING:** A retrospective case notes study from a prospective patient register was used as the study design.

**PATIENT SAMPLE:** A total of 332 PPSDs who underwent posterior spine surgery with a reliable MEP monitoring were collected between September 2010 and December 2014.

**OUTCOME MEASURES:** Relevant MEP loss was identified as rapid amplitude reduction (more than 80% MEP) associated with high-risk surgical maneuvers or high-risk diagnoses.

**METHOD:** The muscles with higher strength were used to record the optimal MEP signal. MEP monitoring of these patients was considered to be feasible if reproducible signals had been obtained; moreover, sensitivity, specificity, positive predictive value (PPV), and negative predictive value were computed. The significance of the patients with rapid MEP loss was analyzed.

**RESULTS:** From a total of 332 PPSDs, 27 cases showed significant MEP loss (23 true positive, 4 false positive), and 21 showed new spinal deficits. Invalid MEP baselines were found in 11 paralysis and 6 severely incomplete paraplegia patients, and success rate of reliable MEP was 95.1% in PPSDs. The congenital kyphoscoliosis, tuberculous kyphoscoliosis, and thoracic spinal stenosis are considered high-risk diagnoses to result in MEP loss. The sensitivity of intraoperative MEP monitoring was 100%, the specificity 98.7%, the positive predictive value 85.2%, and the negative predictive value 100%.

**CONCLUSIONS:** Intraoperative MEP monitoring is feasible for most of the PPSDs. The rapid MEP loss during high-risk diagnoses and complicated surgical procedures may indicate new spinal deficits. © 2015 Elsevier Inc. All rights reserved.

*Keywords:* High-risk surgical maneuvers; Intraoperative monitoring; Motor evoked potential; Preoperative spinal deficits; Rapid MEP loss; Spinal surgery

FDA device/drug status: Approved (Axon Systems Inc).

Author disclosures: ***SW:*** Nothing to disclose. ***YT:*** Nothing to disclose. ***JZ:*** Nothing to disclose. ***JS:*** Nothing to disclose. ***YZ:*** Nothing to disclose. ***HZ:*** Nothing to disclose. ***SL:*** Nothing to disclose. ***BY:*** Nothing to disclose. ***XW:*** Nothing to disclose.

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http://dx.doi.org/10.1016/j.spinee.2015.09.028

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## Introduction

Neurologic injuries are the most feared complications of spine surgery for the treatment of spinal deformity and spinal degeneration. Patients with preoperative spinal deficits (PPSDs; including spinal deformity, spinal degeneration, spinal tumor, etc.) usually have a higher risk of iatrogenic spinal cord injury than patients with normal neurologic function [1–3]. Especially in PPSDs with spinal deformity, which account for a very small portion of patients, such abnormality will significantly increase the risk of neurologic complications during surgery [4,5].

Non-invasive intraoperative motor evoked potential (MEP) monitoring has become an essential component for decreasing the incidence of spinal cord injury [6–8], so most surgeons take it as a necessary security measure. But so far the useful monitoring data for high-risk PPSDs are limited, and the many views of neuromonitoring remains controversial. To help the surgical team know the intraoperative spinal cord function in PPSDs better, we aim at to study patients with different levels of preoperative spinal function deficits which include spinal deformity, spinal degeneration, spinal tumor, etc. Then we further investigate (1) if MEP monitoring is feasible and examine (2) the clinical features of true-positive cases as well as the characteristics of intraoperative MEP loss in PPSDs.

## Patients and methods

### *Patients*

The intraoperative monitoring data of all 332 consecutive PPSDs who underwent posterior spine surgery at our spine center from September 2010 to December 2014 were analyzed. In addition, we collected the clinical features of those patients who presented significant monitoring loss and evaluated their postoperative neurologic function change after 3 months' strict follow-up. The MEPs were recorded at each important surgical point by a veteran monitoring team, and excellent communication was performed during surgery among the electro-physiologist, surgeon, and anesthetist.

### *MEP*

Motor evoked potentials were elicited using subcutaneous needle electrodes by stimulation of constant voltage (from 250 V to 500 V) and multiple trains of 6–7 pulses, with duration of 200–400 μs for each pulse (Axon Systems Inc, Hauppauge, NY). The inter-stimulus interval was 2.5–4.0 ms for each stimulation trains. The filter bandpass was 30–1,000 Hz and the time base was 100-ms window. The stimulation strength for PPSDs would be much stronger than that of a normal neurologic patient. The two pairs of stimulation electrodes were inserted subcutaneously into the motor cortex regions C3–C4. *Recording muscles:* To obtain optimal MEP waveform in the limbs of PPSDs, we recorded it at the muscles with higher strength (quadriceps, tibialis anterior, flexor hallucis longus, gastrocnemius, biceps femoris, abductor hallucis, etc.). However, the MEP baselines of a patient with lower extremity motor weakness of 0–1/5 strength for specific muscle groups often cannot be recorded reliably even if the maximum MEP stimulation strength are used; for instance, there is no MEP in our paralysis (11) and incomplete paraplegia (6) patients.

### *Anesthesia methods*

General anesthesia was induced with a bolus dose of propofol (3 mg/kg) and fentanyl (2.5 ug/kg) combined with a short-acting muscle relaxant and inhalation agents (sevoflurane or nitrous oxide). No muscle relaxants or inhalation agents were given after induction and intubation. Subsequently, maintenance of anesthesia was propofol (5–8 mg/kg/h) based on hemodynamic response; remifentanyl (0.1 ug/kg/min) and a total dose of 5–6 ug/kg fentanyl (intermittent infusion) were used during the whole operation. Here we had to point out that the MEP deterioration involved in this study was based on ruling out systemic and anesthetic factors. Stable anesthesia management is necessary for accurate monitoring.

### *Warning criteria*

In our present study, rapid amplitude loss (more than 80% MEP) associated with high-risk surgical maneuvers (including osteotomy, spinal decompression, closing wedge osteotomy, cervical laminoplasty, etc.) were considered as positive [9]. If MEP amplitude and waveform could not improve after optimizing stimulus parameters and excluding systemic and anesthetic factors, the surgical team must be informed.

*True-positive:* This includes two kinds of situations: (1) MEP loss persisted then presented a corresponding new neurologic deficit; (2) MEP loss and then recovery after adopting corrective measures, and patient had no new neurologic deficit. *False-positive:* MEP loss persisted despite corrective measures and no postoperative neurologic deficits. *True-negative:* There is no MEP loss and no new neurologic deficit. *False-negative:* There is no MEP loss but new neurologic deficit.

### *Statistical analysis*

Statistical comparisons were made by $\chi^2$ test using SPSS software (IBM SPSS Statistics for Windows, Version 19.0, IBM Corp, Armonk, NY, USA), and $p<.05$ was considered statistically significant.

## Results

Table 1 shows the characteristics of diagnosis and muscles strength distribution. There were 27 patients (Table 2) showing significant MEP loss, 23 of these were true positive and 4 were false positive cases; 21 new spinal deficits; 13 transient spinal deficits; and 8 permanent spinal deficits. The sensitivity of intraoperative MEP monitoring was 100%, the specificity 98.7%, the positive predictive value 85.2%, and the negative predictive value 100% (Table 3).

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