Alarm Value of Somatosensory Evoked Potential in Idiopathic Scoliosis Surgery

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■ BACKGROUND: **Somatosensory evoked potential (SSEP) monitoring is performed to examine postoperative clinical findings when a monitoring event was noted intraoperatively and to ascertain the alarm threshold for intraoperative neural damage.**

■ METHODS: **The tibial SSEP of both lower limbs was recorded intraoperatively in patients with idiopathic scoliosis. Change of SSEP amplitude as opposed to the baseline was categorized into 4 levels: decrease <40%, decrease of 40%–50%, decrease of 50%–60%, and decrease >60%. Postoperative neurologic function of patients was examined and compared with SSEP data.**

■ RESULTS: **The baseline amplitude before incision was significantly different from the amplitude after spine exposure. An amplitude reduction of >60% during scoliosis correction procedures was observed in 6 legs, and 4 of them had postoperative deterioration in motor status. As the measure of threshold for alarm, an amplitude reduction of >50% compared with baseline resulted in more false-positive outcomes compared with amplitude attenuation of >60%.**

■ CONCLUSIONS: **Compared with the traditional SSEP baseline before skin incision, the baseline acquired after spine exposure results in more accurate monitoring. A >60% decrease in SSEP amplitude could be a more suitable alarm threshold.**

INTRODUCTION

Surgery for idiopathic scoliosis poses significant risk to patients' postoperative neurologic well-being. Severe neurologic sequelae are infrequent but disastrous for patients with idiopathic scoliosis. Preserving the integrity of the spinal cord during a surgical maneuver is of utmost importance. Intraoperative neurophysiologic monitoring (IOM) provides guidance to surgeons and reduces the risk of permanent neurologic complications. The use of IOM has become widespread, and it is now the standard of care for many spinal surgeries, especially idiopathic scoliosis surgery. The most frequently used IOM modality is somatosensory evoked potential (SSEP).[1-3] SSEP monitoring for scoliosis was pioneered in the 1970s[4] and has been extensively used as a monitoring strategy since then. Traditionally, the SSEP amplitude recorded before skin incision is used as the reference baseline[5,6]; a 50% decrease in the amplitude from baseline is set as the alarm threshold.[3,6-11]

In the application of SSEP, maintaining a stable baseline is important. SSEP can be affected by various factors. For example, anesthesia induces amplitude change at the early stage of operation; reduced core temperature or hypotension exerts an influence during surgery.[12,13] Most researchers have adopted the SSEP amplitude before skin incision but after anesthesia as the baseline, yet some researchers have adopted the amplitude after exposure of the spine but before instrumentation.[14,15] There is no consensus at this point about the determination of SSEP baseline.

A decrease in SSEP amplitude of >50% of baseline is generally accepted as an alarm threshold for intraoperative neural damage.[3,9,10] However, the use of this threshold results in a high frequency of false-positive alerts during monitoring, which can affect the surgical procedures to various degrees. For this reason, a

Key words
- Alarm criterion
- Amplitude
- Idiopathic scoliosis
- Monitoring
- Somatosensory-evoked potential

Abbreviations and Acronyms
IOM: Intraoperative neurophysiologic monitoring
SSEP: Somatosensory evoked potential
TcMEP: Transcranial motor evoked potential

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decrease of >60% of baseline has been used as the alarm threshold in some cases.[15,16]

Despite the wide use of SSEP in corrective scoliosis surgery, there is a paucity of literature regarding its baseline and the comparison between the different thresholds for alarm. A more reasonable baseline and alarm threshold of SSEP would enable a more accurate neural function assessment and more reliable guidance to surgeons during the operation. In the present study, we analyzed the intraoperative neurophysiologic changes and postoperative neurologic deficits of patients with idiopathic scoliosis, with the aim to determine a better SSEP baseline from the existing ones and to determine the change of SSEP amplitude as the alarm threshold for spinal cord injuries during the surgical procedures.

MATERIALS AND METHODS

The present study was approved by the ethics committee of the Second Affiliated Hospital of Xi'an Jiaotong University, and all experiments were carried out in accordance with the approved guidelines of Xi'an Jiaotong University. Informed consent was signed by all recruited patients.

Patients

The medical records of patients with idiopathic scoliosis undergoing spinal deformity correction from January 2005 to December 2010 were retrospectively reviewed. Patient data examined included age, sex, radiologic findings, operative reports, anesthesia records, and intraoperative monitoring records. All patients underwent formal neurologic evaluation. Patients with previous spine surgery, additional intraspinal lesions[17-26] besides spinal deformity, abnormal preoperative neurologic findings, spinal tuberculosis, or other kyphotic deformities were excluded. Also, patients who had no waveforms at the beginning of surgery or a distortion of the waveforms at baseline were excluded from the cohort.

Recording Protocol

Intraoperative neurophysiologic monitoring in all patients was accomplished with 32-channel neurophysiology workstations (Nicolet Endeavor; VIASYS Healthcare, Madison, Wisconsin, USA) by the same monitoring team. SSEP monitoring was routinely used in all cases. Transcranial motor evoked potential (TcMEP) was recorded in some patients but not all patients because signals had inherent variability, and anesthesia interfered with monitoring. General anesthesia was induced intravenously with a mixture of midazolam (0.05 mg/kg), propofol (1.0–2.0 mg/kg), cisatracurium besylate (0.2–0.5 mg/kg), and fentanyl (0.02–0.05 mg/kg). Maintenance of anesthesia during surgery was achieved by continuous infusion of propofol (2.0 mg/kg/hour) and remifentanil (0.1–0.15 mg/kg/hour) and inhalation sevoflurane (0.8%–2%). The patient was placed in prone position, and electrophysiologic monitoring electrodes were applied. Stimulation and recording were performed using subcutaneous needle electrodes. SSEP was elicited by stimulating the posterior tibial nerve at each inner ankle by constant-current square-wave electrical pulses of 200 ms duration, 20–40 mA intensity, and 3.1 Hz stimulation rate. The bandpass filters were set at 30 Hz and 1000 Hz, and 200 to 300 trials were averaged. Resistance of all electrodes was controlled to stay below 5 kΩ. Recording electrodes were placed at Cz' and referenced to FPz according to the international 10–20 scalp positioning system.[27] After anesthesia in steady state, recordings in all patients were made; thereafter, the recording parameters were maintained throughout the surgical procedure. SSEP was recorded at 3 points during the surgery: after anesthesia but before skin incision (postanesthesia), after exposure of the spine but before instrumentation (postexposure), and after segmental instrumentation and correction (postcorrection). After P40–N50 was identified, the peak-to-peak amplitude was measured electronically. Signal changes during the procedures were recorded.

Data Collection

All patients underwent neurologic examination during the first 24 hours after surgery. Neurologic status was graded as either stable or deteriorated compared with the preoperative status. Patients were classified into 1 of 2 groups according to whether or not they had a new postoperative deficit. Any new motor dysfunction of the spinal cord was considered a significant postoperative deficit. SSEP amplitude was recorded in both legs because the amplitude was frequently asymmetric. These SSEP recordings were analyzed throughout the case for changes in baseline, amplitude, or threshold to determine possible spinal cord injury.

Classification of SSEP Amplitude Variation

SSEP changes with a duration of >10 minutes were recorded. Fluctuations in the amplitude were disregarded. An intraoperative alert was defined as a persistent (over at least 10 minutes) loss of >50% or 60% of the amplitude of SSEP relative to a stable baseline. The reduction of the amplitude compared with baseline was categorized into 4 levels: <40% decrease from baseline (level 1), 40% to <50% (level 2), 50% to <60% (level 3), and >60% (level 4).

Statistical Analysis

Statistical evaluations were performed using SPSS for Windows 16.0 (SPSS, Inc., Chicago, Illinois, USA). A t test was used to assess significant variation of the baseline. $P < 0.05$ was considered statistically significant. To evaluate the stability of intraoperative amplitudes between 2 baselines, mean and SD were calculated. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated. A true-positive result was defined as a new postoperative motor deficit with or without sensation, depending on a positive Stagnara wake-up test, which assesses motor rather than sensory function of the patient intraoperatively and has always been considered the gold standard of IOM.[9] A false-positive result was the presence of an amplitude decrease from baseline over the set threshold during the surgical procedure, which was not followed by a notable neurologic deficit after surgery.

RESULTS

The inclusion criteria were met by 89 patients (35 male and 54 female). The average age of patients was 15.8 years ± 5.1 (range, 6–33 years). Coronal Cobb angles were 35°–95° with an average of