

# Intervention mechanisms and outcomes in somatosensory evoked potential monitoring during scoliosis surgery

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## Abstract

**Objective:** Somatosensory evoked potentials (SSEPs) are now routinely used to monitor the integrity of the sensory pathways of the spinal cord during major corrective spinal deformities surgery. We have reviewed retrospectively the outcomes and course of action for a 137 electrophysiologically monitored procedures over a five year period. **Methods:** Responses were recorded via a bipolar epidural electrode positioned in the epidural space at levels T1/T3 prior to surgery. An initial baseline SSEP waveform was recorded early in the surgical procedure and subsequent recordings were compared with those. A decrease of 50% in amplitude or an increase of 10% in latency of the SSEP waveform was used as a threshold for intervention. **Results:** Our findings demonstrate that a drop in amplitude greater than 50% occurred in 46 monitored procedures and whilst the traces of 22 patients remained below the acceptable levels for the subsequent duration of the surgery, there was no evidence of any clinically detectable neurological impairment. Of the 32 interventions by the surgical team to restore the SSEP waveform, only 18 were successfully restored to above the 50% level. None of the SSEP waveforms that were not restored to acceptable levels exceeded a 75% drop in amplitude. **Conclusion:** There were no reports of postoperative neurological deficit and it is probable that the true boundaries at which the critical levels for intervention resides is probably between 50 % and 75%.

## INTRODUCTION

Complex spinal surgery carries a significant risk of postoperative neurological impairment and surgically induced morbidity. The incidence of severe postoperative deficit has been reported to be 0.25 to 3.2% for scoliosis surgery<sup>1,2</sup>. Somatosensory evoked potentials (SSEP) are now routinely used intra-operatively to monitor integrity of the neural pathways. The principal aim of SSEP monitoring is to identify any surgically induced neurophysiological changes and to allow for their prompt correction, thus reducing the risk of postoperative neurological sequelae.

## METHODS

In this retrospective study we examined 137 monitoring procedures of major corrective spinal deformities surgery on a total of 93 patients where SSEP monitoring was used as part of routine clinical practice over a five year period (2003-2007). Of these 137 monitoring procedures, 44 were anterior release followed by posterior correction within 2 weeks, 71 were posterior correction and instrumentation; and a further 22 were anterior release plus posterior correction with instrumentation within one surgical session. Of the 71 posterior correction procedures, 27 patients were not

monitored during anterior release.

The Nicolet Endeavour system from Viasys (Warwick, U.K) was used to perform the intra-operative monitoring of the sensory pathways. Rectangular biphasic pulses of 200µsec at a frequency of 9.9Hz were used to stimulate the posterior tibial nerve at the popliteal fossa and a total of 256 sweeps were averaged to obtain the evoked response. A user selectable stimulation current (with a maximum setting of 100mA) was set to obtain an initial baseline to which successive responses are compared. Responses were recorded via a bipolar epidural electrode positioned in the epidural space at levels T1/T3 prior to surgery. The temperature and blood pressure of all patients were logged at the onset of surgery and when there were any observed changes in the baseline trace as they can affect electrophysiological responses.

An initial baseline SSEP waveform was recorded early in the surgical procedure and subsequent recordings were compared with those. A decrease of 50% in amplitude or an increase of 10% in latency of the SSEP waveform were used as thresholds for intervention and were classified as being

abnormal intra-operative neurophysiological monitoring (INM) events. These events are described as “true positive” if followed by postoperative neurological deficit; and “false positive” if there is no postoperative neurological deficit.

A false positive could occur if the change in SSEP waveform was either not sufficient that neurological deficit developed or that or that any deficit has been reversed through intervention.

**RESULTS**

From the 137 recordings there were 46 instances when the SSEP waveform fell to below acceptable levels of 50% and an INM event was identified. In 32 (69.5%) of these cases the surgical team intervened to restore the SSEP waveform and the results are summarised in Table 1. In 14 (30.5%) cases no intervention was sought.

From the 32 interventions, 18 were classified as successful whereby the SSEP responses recovered to above the 50% level. However none of the traces for patients who had a successful wake up test recovered to their minimum acceptable levels of 50% yet none of those who had a wakeup test had any evidence of spinal deficit. In one patient the haemoglobin level numbers dropped to 5.9g/dl but infusion of 3 units of blood resulted in a full recovery of the trace to its baseline levels. An increase in latency of up to 1ms was quite common with decrease in body temperature of the patient and is not to be associated with any post operative neurological changes.

**Figure 1**

Table 1: Intervention and outcomes

Type of Intervention	No. of false positives acted upon	No. of traces recovered.	As a % of total Interventions
Increased B. P.* and vascular stabilisation	29	11/29	34.3%
Undo Correction	6	3/6	9.4%
Wake Up test (Stagnara)	14	None	No deficit
Patient repositioning	3	3/3	9.4%
Increased Haemoglobin levels	1	1/1	3.1%

\* Blood Pressure

In the intervention group of 32, restoration of the blood pressure to that of the patient’s baseline values (or induced hypertension), returned the SSEP amplitude to above the 50% level in 11 patients; in 6 cases it was necessary to undo the degree of correction and in a further 3 cases, repositioning the patient and un-breaking the operating table returned the traces to normal levels. In 14 cases it was

necessary to do a wakeup test and despite all these patients having had a successful wakeup test, their SSEP traces remained at below acceptable levels for the rest of the surgery. None of the 46 patients who had an abnormal SSEP had any post operative deficit.

**NO INTERVENTION GROUP**

In 14 (30.5%) incidences there was no intervention for several different reasons (Table 2).

**Figure 2**

Table 2: False Positives with No Intervention (Total = 14)

Reason for lack of intervention	Number of Patients
• Blood loss a priority	1
• Borderline trace at 50%	1
• Spontaneous recovery	3
• Procedure near the end	7
• Accidental dislodgement of electrode	2

There was no evidence of a “True Positive” outcome in either the intervention or non-intervention groups.

**DISCUSSION**

During Intra-operative monitoring the SSEP waveform may change for a variety of reasons and the interpreter must distinguish between the many possible causes of such a change, which include but are not restricted to technical factors, effects of anesthesia or compromise of the sensory pathways

Noordeen et al<sub>4</sub> investigated neurological outcomes at 3 levels of loss of SSEP waveform; 25%, 50% and 75% in patients with neuromuscular scoliosis who had operative corrections. Their findings showed that at 75% loss of waveform amplitude, the number of false positive results were reduced but resulted in an unacceptable number of false negatives. In our study the drop in SSEP waveform did not exceed 75%.

Forbes et al<sub>3</sub> reported on a total number of 1168 SSEP monitoring procedures over a period 10 years from 1981 to 1990. The cases included 67% idiopathic scoliosis, 21% congenital or neuromuscular and 6.5% osteogenic spinal deformity, with a small number of for post-traumatic cases. Of these 119 patients were reported to have a drop of more than 50% in their SSEP waveform, of which 32 had clinically detectable neurological changes postoperatively. In 52 patients with significant SSEP changes no detectable neurological changes were noted.

In our study, a total of 46 (33.6%) separate incidences of an abnormal event were reported. In 32 cases the team reacted intra-operatively whereas in the remaining 14 cases no intervention was deemed necessary. In this latter group there were 3 spontaneous recoveries of the SSEP traces. In 7 patients the SSEP waveform dropped below acceptable levels between correction and skin closure, none of these patients had any form of neurological impairment. No postoperative deficit was observed in the non-intervention group despite the traces of 11 patients not returning to acceptable levels by the end of the surgery.

As no patients had clinically detectable neurological impairment, it is not possible to calculate the percentage of true positives. However, the false positive rate is rather high regardless of how it is calculated (33.6% vs. 23.5% if the 18 cases of reversible SSEP changes after intervention are counted as true positives) in comparison to other SSEP studies. It is unclear why this variation exists between this and other studies<sup>3,4</sup>. A more detail analysis of the depth of anesthesia, and percentage reduction and changes in baseline and a wake blood pressure might provide an insight into the unusually high rate of false positives.

In addition to the 137 cases there were a further 10 incidences where it was not possible to record any SSEP traces intra-operatively. As a result, 7 operations were abandoned and 3 proceeded without spinal cord monitoring. Two of the abandoned cases were attributed to a faulty batch of electrodes and 5 to the severity of the neurological deficit of the patients. The incidence of spinal deficits is 0.7%, which is at the lower end of the national average<sup>12</sup>.

There are many studies of neurophysiological monitoring during corrective scoliosis surgery and SSEPs have been shown to have decreased sensitivity for detecting neurological injury compared to MEPs<sup>5</sup>. These days however the trend is to have combined monitoring of motor and sensory evoked potentials and it is hoped that the implementation of combined MEP and SSEP monitoring will help reduce the number of true and false positive incidents.

## CONCLUSION

In this series of patients none of the 46 who had an abnormal SSEP had any post operative deficit. The incidence of false positives (33.6%) was higher than expected and our experience indicates that this term needs to be redefined for intra-operative use. However, the analysis of the cause

indicates that while a significant percentage may be attributed to known risks such as reduced segmental cord blood flow, cord distraction, concentration of inhalation anaesthetic, there are also a significant number (25/137) of unexplained incidents.

These results indicate that a drop in amplitude of greater than 50% of the baseline trace does not necessarily result in postoperative deficit. In our study there were no instances where the latency increased beyond the 10% threshold or where the fall in amplitude exceeded 75%. It is probable, from these results that the true boundaries at which the critical level of intervention resides is between the limits of 50% and 75%. However, it would be unethical to test this hypothesis in practice and more data is required from cases where traces have failed to recover to above the established intervention levels of 50% during surgery.

Clearly when using SSEP monitoring only, our experience is not in total agreement with those of other researchers, but we must emphasise that a drop of greater than 50% of the baseline trace should not be ignored. Our findings demonstrate that a drop of 50% from the baseline is perhaps not the optimum level for intervention.

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