Analysis of 5317 Consecutive Pediatric Spinal Deformity Intraoperative Neuromonitoring (IONM) Alerts: Importance of Normotension at Correction and IONM Recovery

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INTRODUCTION:

Spinal cord dysfunction after pediatric spinal deformity is a devastating potential complication. Use of intraoperative multimodal neuromonitoring (IONM) to monitor sensory and motor tracts is considered standard of care because it decreases the frequency of postoperative spinal cord dysfunction by facilitating corrective actions. However, there is little information regarding the timing of alerts during surgery or on the specific maneuvers used to recover IONM data to baseline. The purpose of this study is to identify the chronology of IONM alerts during pediatric spinal deformity surgery, the subsequent corrective maneuvers, and the short-term and final neurological outcomes.

METHODS:

This study was a retrospective case series. An institutional neuromonitoring database was reviewed (11/1992–4/2024) to identify all consecutive patients ages (0–18 years) with at least one IONM alert who underwent pediatric spine deformity surgery at one of our three tertiary-care institutions. IONM alert criteria were defined as a 10% increase in response latency and/or a 60% decrease in amplitude for somatosensory-evoked potentials (SSEP); a 10% increase in response latency and/or an 80% decrease in amplitude for transcranial electrical motor-evoked potentials (TCeMEPs); and a 100-volt increase in stimulation intensity above response elicitation threshold for descending-neurogenic evoked potentials (DNEPs). Statistics were completed using SPSS (Version 29.0.2.0).

RESULTS:

A total of 223 patients (4.2%) were identified out of 5317 consecutive cases. The mean age was 13.9 years (114 females, 109 males). Diagnoses included kyphosis (n=66), idiopathic scoliosis (n=63), neuromuscular (n=43), congenital (n=24), syndromic (n=11), and others (n=16). Surgical procedures included 199 posterior spinal fusions, 19 anterior spinal fusions, and 5 combined anterior and posterior spinal fusions. Preoperative neurologic status was normal in 171 patients, abnormal in 50 patients, and unknown in 2. There were 235 alerts, as 12 patients had multiple IONM events. The most common time points for data loss included correction or following correction (42%), followed by decompression (24%), and placing instrumentation (24%) (Figure 1). The most common alert modality was TCeMEP/DNEP only (n=108, 48%), followed by SSEP and TCeMEP/DNEP (n=59, 26%), and SSEP only (n=56, 25%). Among TCeMEP/DNEP modalities, 98 alerts were produced by DNEPs only, 65 alerts were produced by TCeMEPs only, and simultaneous alerts from both DNEPs and TCeMEPs occurred 4 times. There were 347 corrective actions detailed in Table 1. Correction of hypotension was the most common action, used in 91 cases (42%), followed by adjustment of deformity correction (n=63, 28%). Among all alerts, 74 had documentation of mean arterial pressure (MAP) at the time of the alert (66.5+/-13.4 mmHg) and 61 had documentation at resolution (86.3+/-12.5 mmHg). Thus, the difference in average MAP between alert onset and resolution was 19.8 mmHg. Postoperative neurologic change was observed in 34 patients (15.2% of 223 patients; 0.6% of 5,317 cases), of which full recovery was observed in 21, partial recovery as observed in 5, no recovery was observed in 3. Final outcomes were unavailable for 5 patients. The worst-case scenario, or persistent neurologic change, occurred in 5.8% (13/223). 160 patients had data recovery intraoperatively: 150 (94%) awoke w/ normal exam, and 157 (98%) had no change from preoperative neurological status at final follow-up. 63 patients did not have data recovery: 39 (62%) awoke with normal exam, and 53 (84%) had no change from preoperative neurological status at final follow-up. A significant association existed between both immediate and final neurologic outcomes and the return of data before surgery completion ($p<0.001$). In cases with an IONM alert without data recovery, 16 surgeries were aborted. The laterality of the alerts (n=69; 30 unilateral, 39 bilateral) was not predictive of postoperative neurological outcomes. Overall, at wake-up, 0.6% of all patients (34/5317) had neurologic change and worst-case scenario was 0.24% (13/5317) at final neurologic exam.

DISCUSSION AND CONCLUSION:

In this largest single-center experience with IONM of 5317 consecutive pediatric spinal deformity surgeries, IONM alerts occurred in 4.2% of cases, of which 15.2% had neurological change from baseline at conclusion of surgery. The most common time for alerts was associated with correction (42%, n=99) and most common corrective action was correction of hypotension (42%, n=91) and release of correction (n=63, 28%). 157 of 160 (98%) of patients with recovery of IONM data during surgery made a complete recovery, whereas 53 of 63 patients (84%) without made a complete recovery. The return of baseline data quality was significantly associated with neurologic outcomes both postoperatively and at final exam. Intraoperative corrective actions after an IONM alert potentially decreased spinal cord dysfunction from 4.2% intraoperatively, to 0.6% at wake-up, to 0.24% (13/5317) at final exam. This study supports the use of an IONM alert protocol to optimize outcomes and enable optimal preoperative shared-decision making.

Table 1: Total Actions Taken to Resolve Neuromonitoring Event

Action Taken	
No Intervention	14
Suspected Anesthesia – Neuromuscular Blockade	2
Adjust/Remove instrumentation	26
Decompression	21
Correction Adjustment	63
Raise Blood Pressure	91
Decrease Anesthetic	27
Reposition Patient	31
Transfusion/Administer Blood Products	7
Raise Body Temperature	1
Correction of Poor Pulmonary Ventilation	1
Abort	16
Reduce Traction	28
Reposition Retractors	12
Other	7
Total	347

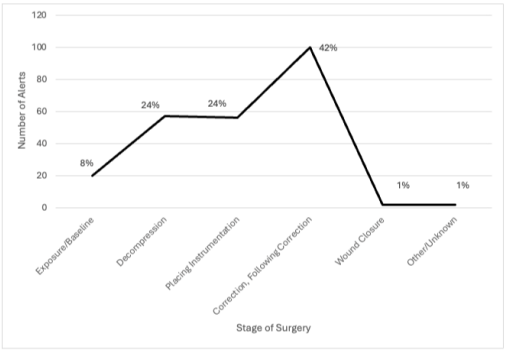

Figure 1: Chronology of IONM events