The evidence for intraoperative neurophysiological monitoring in spine surgery: does it make a difference?

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CRD summary
This review concluded that multimodal intraoperative monitoring (MIOM) was sensitive and specific for detecting neurologic injury during spine surgery; MIOM should be considered where the spinal cord or nerve roots were at risk. A wide range of sensitivities and specificities and considerable clinical heterogeneity across studies made the generalisability of the results uncertain and the conclusions seem overly strong.

Authors’ objectives
To determine whether intraoperative neurophysiological monitoring (INM) can accurately detect intraoperative neurological injury during spinal surgery and improve outcomes.

Searching
MEDLINE, EMBASE and The Cochrane Library were searched for English-language publications from 1990 to December 2008; search terms were not reported. Bibliographies of key articles were searched.

Study selection
Two types of study were included for adults who underwent spinal surgeries: diagnostic accuracy studies that evaluated somatosensory-evoked potentials (SSEPs), spinal motor-evoked potentials (MEPs) or multimodal intraoperative monitoring (MIOM); and any study that compared the diagnostic test characteristics of SSEPs, MEPs, MIOM or spontaneous electromyographic activity in the same population. Studies that reported worsening postoperative neurologic events (either in patients who did not have INM or where the surgeon did not react to positive results of INM) were included.

Mean age of participants ranged from 14 to 63 years. The proportion of males ranged from 25% to 73%. The population varied widely across studies in terms of diagnosis (whole spine or restricted to a particular region), reasons for surgery (scoliosis, tumours, fractures, congenital disorders, myelopathy, arthritic conditions) and surgery undertaken (corrective surgery, decompression, laminotomy, laminectomy, vertebrectomy, tumour resection and excision). The most common threshold for a positive test was a decrease in amplitude of more than 50%. Most studies used a new postoperative sensory or motor deficit as the reference standard.

Two independent reviewers selected studies for the review; disagreements were resolved by consensus.

Assessment of study quality
Study quality was assessed by two independent reviewers in terms of patient recruitment and spectrum, descriptions of tests evaluated and blinding of the interpreters of tests. The assessment results were used to assign a level of evidence.

Data extraction
Incidence rates of neurological deficits were extracted and sensitivity, specificity, and positive and negative predictive values were extracted or calculated.

The authors did not state how many reviewers extracted data.

Methods of synthesis
Studies were combined in a narrative synthesis. Ranges for the outcomes of interest were reported. Differences between studies were discussed in the text. Study details were tabulated in an on-line appendix.

Results of the review
Thirty-two studies met the inclusion criteria (n=10,269 participants, range 35 to 1,121). Twenty-six studies were retrospective. Overall, study quality was considered to be low for studies that assessed unimodal methods (SSEPs and MEPs), high for studies that assessed MIOM and high for studies that directly compared unimodal methods.

**SSEPs**: The rate of new neurological deficits ranged from 0.09% to 28.5% (18 studies). Sensitivity ranged from 0% to 100% (15 studies). Specificity ranged from 27% to 100% (15 studies). Positive predictive values ranged from 15% to 100% (nine studies). Negative predictive values ranged from 95% to 100% (nine studies).

**Transcranial MEPs**: The rate of neurological new deficits ranged from 0.8% to 3.2% (six studies). Sensitivity ranged from 81% to 100% (six studies). Specificity ranged from 81% to 100% (six studies). Positive predictive values ranged from 17% to 96% (three studies). Negative predictive values ranged from 97% to 100% (three studies).

**Electromyographic activity**: A single study reported 3.2% new neurological deficits, 46% sensitivity, 73% specificity, 3% positive predictive value and 97% negative predictive value.

**MIOM**: Rates of new neurological deficits ranged from 4.9% to 28.5% (11 studies). Sensitivity ranged from 70% to 100% (11 studies). Specificity ranged from 53% to 100% (11 studies). Positive predictive values ranged from 5.2% to 100% (three studies). Negative predictive values ranged from 96% to 100% (three studies).

When unimodal methods were compared in the same patients during the same surgical procedure, MEP outperformed SSEPs and electromyographic activity; none of the studies directly compared MIOM with a unimodal method. Further results were presented in the paper.

**Authors' conclusions**
MIOM was sensitive and specific for detecting intraoperative neurologic injury during spine surgery; MIOM should be considered where the spinal cord or nerve roots were deemed to be at risk.

**CRD commentary**
The review addressed a clear question supported by appropriate inclusion criteria. Three relevant sources were searched. Search terms were not reported and it was unclear whether a diagnostic filter was used, which could mean that studies were missed. The search was restricted to published studies in English, which risked publication and language biases. Study selection and quality assessment were conducted in duplicate; it was unclear whether similar methods to reduce error and bias were employed during data extraction. Study quality was assessed using appropriate criteria and results were reported for each study in an online appendix. Use of a narrative synthesis seemed appropriate given heterogeneity across studies.

Given the wide range of sensitivities and specificities reported and considerable clinical heterogeneity across studies, the reliability and generalisability of the results remains uncertain and the conclusion seems overly strong.

**Implications of the review for practice and research**

**Practice**: The authors stated a need to define an evidence-based protocol to deal with intraoperative changes in neuroimaging.

**Research**: The authors stated that comparisons of postoperative neurologic injuries in patients who did/did not receive neuroimaging, and neurologic injury in patients who got neuroimaging where there was/was not a response to a positive alert would assist surgeons in decision-making. They stated that evidence-based protocols developed to deal with intraoperative changes in neuroimaging should be evaluated prospectively.

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