Neurosurgical Forum LETTERS TO THE EDITOR

Intraoperative neurophysiological monitoring: an anesthesiologist's point of view

TO THE EDITOR: I read with interest the recent article by James et al.³ (James WS, Rughani AI, Dumont TM: A socioeconomic analysis of intraoperative neurophysiological monitoring during spine surgery: national use, regional variation, and patient outcomes. *Neurosurg Focus* 37(5):E10, November 2014).

Monitoring of motor and somatosensory evoked potentials (MEPs and SSEPs) has been used in many surgical procedures to reduce the risk of neurological damage. There is evidence supporting the use of intraoperative neurophysiological monitoring (IONM) for spine surgery, in particular.⁵ It is also increasingly used in the resection of tumors in the eloquent cortex; brainstem surgery; in the treatment of carotid artery, cerebral, thoracic, and abdominal aneurysms; and in thyroid and esophagus surgery.

As James et al. state, there is not yet a consensus supporting the use of IONM in spinal surgery, with the exception of scoliosis, spinal revision, and intramedullary spinal tumor surgeries, but there has been a dramatic increase in the use of IONM in low-risk spinal surgeries. Therefore, there are some topics to discuss:

1. Are IONM results reliable?

Successful IONM requires a proper anesthetic technique. Evoked potentials are more sensitive to inhalational anesthetics and nitrous oxide. The use of neuromuscular blockers is contraindicated for the monitoring of MEPs. Propofol, ketamine, etomidate, dexmedetomidine, and opioids are preferred for IONM, and all of these anesthetic agents are more expensive than inhalational anesthetics. More importantly, the depth of anesthesia should remain constant during surgery and should be carefully monitored using the bispectral index or another technique. Hypotension, hypothermia, hypoxia, anemia, hypercapnia, and electrolyte imbalances all affect IONM,⁹ and these physiological parameters should be kept within the normal ranges. Proper anesthesia management is essential for reliable IONM results.

Alarm criteria for neuronal injury include a decrease in

amplitude of SSEPs by more than 50% and an increase in latency of more than 10%. Although these criteria have been established for SSEPs, the criteria with respect to MEPs vary. Criteria used in the interpretation of MEP monitoring include the absence or presence of MEPs, amplitude reduction, and threshold reduction. Differences in MEP warning criteria may cause differences in study outcomes. Several studies have documented sensitivity and specificity approaching 100% in multimodal neuromonitoring (combination of SSEP and MEP monitoring),⁷ but more recently Hamilton et al.² reported a sensitivity of 43% for the combination of SSEP and MEP monitoring with respect to detection of a new spinal cord deficit. Even worse, the sensitivity for a new nerve root deficit was only 13%.

2. Is this a cost-effective procedure?

Several studies have analyzed the cost-effectiveness of IONM in spine surgery,⁴ but they did not address the possibility of false-negative IONM results. IONM does not prevent every neurological injury. Traynelis et al.⁸ reported that decompression of the cervical spine without IONM may reduce the cost of treatment without causing any adverse effect. In their retrospective analysis of 443,194 spine procedures, James et al.³ found that the rate of iatrogenic nerve and spinal cord injury was less than 1% and that it was not decreased by the use of IONM.

3. Is this an evidence-based procedure?

Prospective randomized controlled trials (RCTs) are absent because RCTs are considered unethical or unnecessary for IONM. However, IONM may pose some serious risks, such as cardiac arrhythmia, seizures, movement-related injuries, scalp burn, and unnecessary interruption of surgery due to false-positive results. Sala et al.⁶ compared the outcome of surgery for intramedullary spinal cord tumors in patients who had intraoperative MEP monitoring with that of a historical control group (treated without IONM), and they found that monitoring improved outcomes. A potential weakness of the use of a historical control group, however, is that differences in outcome may be due to possible changes in anesthesia and surgical techniques.

Two systematic reviews found similar results for IONM in spine surgery.^{1,5} The evidence that IONM can *predict* a neural injury is strong, but the evidence for its effectiveness in *preventing* neural injury is weaker. Does this

mean that surgeons pay no attention to IONM signals during surgery or do the signals arise too late to change the outcome?

In conclusion, I believe that RCTs are needed to verify the efficacy of IONM, especially in low-risk surgery.

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Disclosures

The author reports no conflict of interest.

Response

The letter to the editor written by Dr. Dilmen raises three valid questions regarding the reliability, cost-effectiveness, and evidence-based utility of IONM. Our group is in full agreement that in order to answer these questions with a degree of scientific rigor expected in modern medicine, RCTs would be desirable. RCTs would more definitively answer the questions of IONM utility and reliability, and there is a possibility that results from such trials might drive research and development in the industry, foster new innovation, and promote progress in the development of new technologies for more accurate and reliable IONM techniques.

Unfortunately, such trials would be difficult to complete for three particular reasons. First, use of IONM may be useful for one spinal procedure but not another such that many separate studies or separate study arms would be required. Second, study size would need to be quite large given an anticipated large number needed to treat, especially in the instance of simple or minor spinal procedures. Third, a non-industry funding source would be ideal to prevent industry bias, and a large RCT would be expensive to complete.

Given that there is no clear benefit to IONM for many simple spinal procedures, another approach would be a position statement by leadership in spinal care with recommendations for use of IONM in spine cases. This may curtail further overuse of IONM in spinal surgery as delineated in our index report. We continue to support use of IONM in cases with a theoretically greater likelihood of intraoperative spinal cord or nerve injury, such as in patients with severe spinal cord compression and deformity correction. We presently see no role for IONM in simple spinal procedures such as uncomplicated anterior discectomy, microdiscectomy, or nondeformity spinal fusion cases.

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