

Question of the Month

Does intraoperative neuromonitoring with MEPs and SSEPs during major spine surgery improve post-operative neurological outcomes?

Multimodal intraoperative monitoring (MIOM), including somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs), allows for continuous monitoring of the integrity of sensory and motor pathways during spine surgery. The purported benefit is early recognition of injury and potential reversal or amelioration of neurologic deficits. The use of MIOM during complex spine procedures, such as intramedullary tumor resection and major deformity correction, has become widespread and is often referred to as “standard of care”^{1,2}. However, while the diagnostic value of MIOM is well described, there is a lack of evidence for its therapeutic value or, in other words, its ability to improve patient-centered outcomes.

There is no prospective data on the ability of MIOM to improve patient outcomes. While there is retrospective data, the majority of it is Level III evidence due to methodological and/or statistical flaws³⁻²⁴. The highest quality of evidence for the therapeutic potential of MIOM in major spine surgery comes from two papers, Choi et. al. in 2014²⁵ and Harel et. al. in 2017²⁶, both of which investigated its use in intramedullary tumor excision. Both showed MIOM to be sensitive and specific for detecting new neurological injury, but neither found any difference in rates of post-operative neurological deficits between subjects who underwent surgery without MIOM and those who had MIOM.

Even when looking at the studies that do suggest therapeutic benefit, it is difficult to know how to apply the information clinically. There is significant heterogeneity within and between study populations in terms of surgical procedures and patient demographics, comorbidities, and pre-existing neurologic deficits^{3,4,8,20,22,27,28}. Furthermore, the steps taken to address intraoperative neurologic injury differs between studies or is frequently not described. Current management is primarily based on physiologic reasoning and differs between institutions and individuals^{1,2}.

Overall, the diagnostic utility of MIOM is unquestionable. Numerous studies have shown excellent sensitivity and specificity for the detection of neurologic injury across a wide range of spine procedures. Unfortunately, the ability to use this diagnostic information to improve patient-centered outcomes has been under-studied and the highest quality evidence available for its use in major spine surgery suggests no benefit. For these reasons, the 2017 guidelines from *Neurosurgery* concluded that “the use of IOM during spinal cord or spinal column surgery cannot be considered a “standard of care””¹. Practically, MIOM has been widely integrated into spine surgical practice and this is unlikely to change. Therefore, to advance patient care and improve outcomes, high quality studies are needed to determine when MIOM is most useful and what steps should be taken once neurologic injury is detected.

1. Hadley MN, Shank CD, Rozzelle CJ, Walters BC. Guidelines for the use of electrophysiological monitoring for surgery of the human spinal column and spinal cord. *Clin Neurosurg*. 2017. doi:10.1093/neuros/nyx466
2. Charalampidis A, Jiang F, Wilson JRF, Badhiwala JH, Brodke DS, Fehlings MG. The Use of Intraoperative Neurophysiological Monitoring in Spine Surgery. *Glob Spine J*. 2020. doi:10.1177/2192568219859314
3. Epstein N. The surgical management of ossification of the posterior longitudinal ligament in 51 patients. *J Spinal Disord*. 1993. doi:10.1097/00002517-199306050-00011
4. Hilibrand AS, Schwartz DM, Sethuraman V, Vaccaro AR, Albert TJ. Comparison of transcranial electric motor and somatosensory evoked potential monitoring during cervical spine surgery. *J Bone Jt Surg - Ser A*. 2004. doi:10.2106/00004623-200406000-00018
5. Castellon AT, Meves R, Avanzi O. Intraoperative neurophysiologic spinal cord monitoring in thoracolumbar burst fractures. *Spine (Phila Pa 1976)*. 2009. doi:10.1097/BRS.0b013e3181bf151b
6. Riesenburger R. Cervical decompression and reconstruction without intraoperative neurophysiological monitoring. *Yearb Neurol Neurosurg*. 2013. doi:10.1016/j.yneu.2012.08.005
7. Meyer PR, Cotler HB, Gireesan GT. Operative neurological complications resulting from thoracic and lumbar spine internal fixation. *Clin Orthop Relat Res*. 1988. doi:10.1097/00003086-198812000-00018
8. Ghadirpour R, Nasi D, Iaccarino C, et al. Intraoperative neurophysiological monitoring for intradural extramedullary tumors: Why not? *Clin Neurol Neurosurg*. 2015. doi:10.1016/j.clineuro.2015.01.007
9. Tani T, Ushida T, Yamamoto H. Surgical treatment guided by spinal cord evoked potentials for tetraparesis due to cervical spondylosis. *Paraplegia*. 1995. doi:10.1038/sc.1995.79
10. Ueta E, Tani T, Taniguchi S, Ishida K, Ushida T, Yamamoto H. Diagnostic value of cervical somatosensory evoked potentials recorded from the intervertebral discs after median and ulnar nerve stimulation in cervical spondylotic myelopathy. *J Spinal Disord*. 1998. doi:10.1097/00002517-199812000-00011
11. Wiedemayer H, Fauser B, Sandalcioglu IE, Schäfer H, Stolke D. The impact of neurophysiological intraoperative monitoring on surgical decisions: A critical analysis of 423 cases. *J Neurosurg*. 2002. doi:10.3171/jns.2002.96.2.0255
12. Bose B, Sestokas AK, Schwartz DM. Neurophysiological monitoring of spinal cord function during instrumented anterior cervical fusion. *Spine J*. 2004. doi:10.1016/j.spinee.2003.06.001
13. Sala F, Palandri G, Basso E, et al. Motor evoked potential monitoring improves outcome after surgery for intramedullary spinal cord tumors: A historical control study. *Neurosurgery*. 2006. doi:10.1227/01.NEU.0000215948.97195.58
14. Smith PN, Balzer JR, Khan MH, et al. Intraoperative somatosensory evoked potential monitoring during anterior cervical discectomy and fusion in nonmyelopathic patients-a review of 1,039 cases. *Spine J*. 2007. doi:10.1016/j.spinee.2006.04.008
15. Hilibrand AS, Schwartz DM, Venkat Sethuraman D, Vaccaro AR, Albert TJ. Comparison of

- Transcranial Electric Motor and Somatosensory. *J Bone Joint Surg Am*. 2004.
16. Jarvis JG, Strantzas S, Lipkus M, et al. Responding to neuromonitoring changes in 3-column posterior spinal osteotomies for rigid pediatric spinal deformities. *Spine (Phila Pa 1976)*. 2013. doi:10.1097/BRS.0b013e3182880378
17. Visser J, Verra WC, Kuijlen JM, Horsting PP, Journée HL. Recovery of TES-MEPs during surgical decompression of the spine: A case series of eight patients. *J Clin Neurophysiol*. 2014. doi:10.1097/WNP.0000000000000099
18. Traynelis VC, Abode-Iyamah KO, Leick KM, Bender SM, Greenlee JDW. Cervical decompression and reconstruction without intraoperative neurophysiological monitoring. Clinical article. *J Neurosurg Spine*. 2012. doi:10.3171/2011.10.SPINE11199
19. Bhagat S, Durst A, Grover H, et al. An evaluation of multimodal spinal cord monitoring in scoliosis surgery: a single centre experience of 354 operations. *Eur Spine J*. 2015. doi:10.1007/s00586-015-3766-8
20. Nuwer MR, Dawson EG, Carlson LG, Kanim LEA, Sherman JE. Somatosensory evoked potential spinal cord monitoring reduces neurologic deficits after scoliosis surgery: results of a large multicenter survey. *Electroencephalogr Clin Neurophysiol Evoked Potentials*. 1995. doi:10.1016/0013-4694(94)00235-D
21. Kothbauer KF, Deletis V, Epstein FJ. Motor-evoked potential monitoring for intramedullary spinal cord tumor surgery: correlation of clinical and neurophysiological data in a series of 100 consecutive procedures. *Neurosurg Focus*. 2008. doi:10.3171/foc.1998.4.5.4
22. Eager M, Shimer A, Jahangiri FR, Shen F, Arlet V. Intraoperative neurophysiological monitoring (IONM): Lessons learned from 32 case events in 2069 spine cases. *Neurodiagn J*. 2011. doi:10.1080/1086508x.2011.11079827
23. Jin SH, Chung CK, Kim CH, Choi YD, Kwak G, Kim BE. Multimodal intraoperative monitoring during intramedullary spinal cord tumor surgery. *Acta Neurochir (Wien)*. 2015. doi:10.1007/s00701-015-2598-y
24. Sebastián C, Raya JP, Ortega M, Olalla E, Lemos V, Romero R. Intraoperative control by somatosensory evoked potentials in the treatment of cervical myeloradiculopathy. Results in 210 cases. *Eur Spine J*. 1997. doi:10.1007/BF01142677
25. Choi I, Hyun SJ, Kang JK, Rhim SC. Combined muscle motor and somatosensory evoked potentials for intramedullary spinal cord tumour surgery. *Yonsei Med J*. 2014. doi:10.3349/ymj.2014.55.4.1063
26. Harel R, Schleifer D, Appel S, Attia M, Cohen ZR, Knoller N. Spinal intradural extramedullary tumors: the value of intraoperative neurophysiologic monitoring on surgical outcome. *Neurosurg Rev*. 2017. doi:10.1007/s10143-017-0815-2
27. Ney JP, Kessler DP. Neurophysiological monitoring during cervical spine surgeries: Longitudinal costs and outcomes. *Clin Neurophysiol*. 2018. doi:10.1016/j.clinph.2018.08.002
28. Raynor BL, Bright JD, Lenke LG, et al. Significant change or loss of intraoperative monitoring data: A 25-year experience in 12,375 spinal surgeries. *Spine (Phila Pa 1976)*. 2013. doi:10.1097/BRS.0b013e31827aafb9