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Intraoperative Neurological Monitoring by an Anesthesiologist: A Review

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Abstract

Intraoperative neurological monitoring (OPNM) has been considered as an important component of neurosurgical and nonneurosurgical procedures. IONM provides instant feedback concerning neural function and supports the prevention of intraoperative neural injury, enhancing the patient outcomes and the safety. Anesthesiologists play an important role in IONM techniques. In addition to monitoring physiological conditions, anesthesiologists also closely collaborate with the surgical team for interpreting data from monitoring, making appropriate strategies in advance of potential complications. Somatosensory evoked potentials (SSEPs), motor evoked potentials (MEPs), transcranial Doppler (TCD), and electroencephalography (EEG) have significantly increased precision and reliability in IONM. This article reviews the essential elements and components of intraoperative monitoring further underscores the integral place of the anesthesiologist in providing intraoperative care, not merely emphasizing management under anesthesia but neurological monitoring that enhances patient safety while further improving surgical outcomes.

Keywords: Anesthesiology; Intraoperative Monitoring; Neurological Monitoring; Patient Safety; Transcranial Doppler

Abbreviations

OPNM: Intraoperative neurological monitoring; SSEPs: Somatosensory Evoked Potentials; MEPs: Motor Evoked Potentials; TCD: Transcranial Doppler; EEG: Electroencephalography.

Introduction

Intraoperative neurological monitoring has become a critical aspect in the conduct of surgery procedures involving crucial neural structures, providing immediate feedback during an operation about the functional integrity of the nervous system in order to allow surgical interventions to avoid possible damage by the complex procedure. Since its introduction in the mid-20th century, IONM has experienced tremendous evolution, incorporating sophisticated technologies and methodologies to augment its diagnostic and protective functions [1-3]. The anesthesiologist is the key player in this field, bridging the gap between monitoring needs and anesthetic management.

The central nervous system is very vulnerable to surgical interventions due to its tender nature. All procedures which involve the brain, the spinal cord, and the peripheral nerves are prone to both transitory and permanent injury to the neural tissue. IONM thus supports the early detection of any potential neural compromise where immediate intervention may be done in order to modify surgical or anesthesia techniques [4]. Techniques such as SSEPs, MEPs, TCD, and EEG provide a foundation for IONM in assessing sensory function, motor function, or cortical functions.

In the context of IONM, anesthesiologists play a dual role. They have direct responsibility for the administration of anesthetic agents and physiological parameters that can influence the reliability of monitoring directly. On the other hand, they contribute to the interpretation of data and initiate corrective measures when deviations are observed [5,6]. Such a dynamic interplay demands that anesthesiologists have a strong understanding of neurological monitoring principles and proficiency in anesthetic pharmacology and physiology.

This review discusses the complex interplay between anesthesiology and IONM. It traces the historical development, fundamental principles, and practical applications of IONM in surgical settings. This further highlights the need for anesthesiologists to optimize anesthetic protocols, which may face a number of challenges related to efficacy in monitoring and ensuring safety for patients. With these aspects in mind, the article reviews current trends and future directions as a comprehensive overview of the role anesthesiologists play in furthering IONM practice.

Main Article

Intraoperative neurological monitoring has become a basic tool of current surgery, especially if there are manipulations in the nervous system. The possibility of monitoring neural functions in vivo allows one to notice and prevent injuries of potentially vulnerable nerves or parts of the brain, and thus makes patient care much better [7].

This sets the cornerstone for a good success with IONM: a smooth blending of monitoring techniques with the management of anesthetics provided by both anesthesiologists and surgeons. In the arsenal of IONM, principal modalities include SSEPs, MEPs, EMG, TCD, and EEG-all with a unique purpose serving their use in evaluation [8].

Somatosensory Evoked Potentials (SSEPs)

This monitoring technique tracks the sensory pathways from peripheral nerves through to the sensory cortex in terms of integrity. Peripheral nerves like median and posterior tibial nerves are stimulated electrically, and signals recorded over the nervous system at varied levels, which include spinal cord and brain. Mainly, it tests for the dorsal columns of spinal cord and the sensory cortex. Ischemic as well as mechanical injury may be indicated through changes in latency and amplitude of SSEP signal [9-11]. SSEPs are very useful in spinal surgeries, brain tumor resections, and procedures involving the thoracic aorta. Anesthetic agents like volatile anesthetics and nitrous oxide can depress SSEP signals, so total intravenous anesthesia (TIVA) is required for optimal monitoring conditions.

Motor Evoked Potentials (MEPs)

MEPs evaluate the functional integrity of motor pathways, especially the corticospinal tract. They are elicited through transcranial electrical or magnetic stimulation of the motor cortex, with responses recorded in peripheral muscles. MEPs are critical during surgeries that pose risks to motor function, such as spinal deformity corrections and brainstem operations. This modality is highly sensitive to anesthetic depth and neuromuscular blockade. For accurate monitoring, anesthesiologists often limit the use of neuromuscular blocking agents and rely on short-acting intravenous agents like propofol [12-15]. A sudden fluctuation of the amplitude or complete disappearance of MEP may raise concerns about potential neural damage. The surgical team will promptly intervene.

Transcranial Doppler (TCD)

TCD is a non-invasive technique that uses ultrasound for the measurement of cerebral blood flow dynamics. It can be useful in operations, for instance, carotid endarterectomy, cardiac operations, and neurosurgery, in which there needs to be adequate cerebral blood flow. By monitoring the flow velocity of blood in major cerebral arteries, TCD can identify embolism, vasospasm, or hypoperfusion. Anesthesiologists manipulate blood pressure, oxygen, and carbon dioxide levels on the basis of TCD data to maintain cerebral perfusion [16]. Its real-time feedback is essential in stroke and other ischemic complications.

Electroencephalography (EEG)

EEG monitors electrical activity in the brain, giving an outline of cortical function. It is widely applied in neurosurgery, cardiac surgery, and procedures with hypothermic circulatory arrest. EEG detects ischemia, seizure activity, or changes in depth of anesthesia. Patterns, such as burst suppression or alpha variability, can assist in management of anesthesia. For example, EEG can be utilized during carotid endarterectomy in order to identify cerebral ischemia associated with carotid clamping. The choice of anesthetic agents has a significant role in EEG reliability.

Recent Advancements and the Role of Artificial Intelligence in IONM

Technological advancement has transformed intraoperative neurological monitoring landscapes in terms of high-resolution imaging, multimodal monitoring systems, and portable devices aimed at improving precision and the accessibility of monitoring. Another innovation is the integration of AI into IONM, which has opened the horizons of data analysis and predictive modeling. Thus, AI algorithms can run real-time complex neural signal analysis, identify subtle changes in neural signals that might otherwise go unnoticed and, therefore, remain uninterpreted. In addition, machine learning models can also predict outcomes from intraoperative data, thus enabling proactive decision-making [4]. AI-driven technologies are likely to automate some parts of IONM to reduce human error and improve efficiency. For instance, AI can be used in the identification of artifacts, neural signal classification, and correlating physiological changes with surgical events. In other related areas, virtual and augmented reality platforms are in focus to provide immersion training on VR and AR for enhancing anesthesiologists as well as neurophysiologists' performance in more complex cases [7].

Despite these breakthroughs, there are still a lot of challenges in the application of AI in IONM. Data privacy and algorithm transparency are some of the issues that need to be addressed to ensure safe and effective integration of AI in clinical practice. However, the great potential of AI in revolutionizing IONM calls for continued research and innovation in this field. These modalities, individually and collectively, present a very strong framework for intraoperative neurological monitoring. They provide the surgical team with an opportunity to observe and act on potential neural injuries before they occur.

The role of the anesthesiologist in IONM is very multi-dimensional. Monitoring may be significantly affected by both intravenous and inhalational anesthetic agents. Volatile anesthetics such as sevoflurane and isoflurane are particularly known to suppress cortical activity and can affect SSEP and EEG recordings. Neuromuscular blocking agents can disrupt MEPs and EMG signals [6]. Therefore, this places a high demand on anesthesiologists as they need to carefully decide which agents to use along with titration to adequately balance surgical requirements with efficacies in monitoring.

Apart from pharmacological factors, physiological issues of temperature, blood pressure, and oxygenation become quite relevant in IONM. Hypothermia, hypotension, and hypoxia could, for example, influence the pattern of neural conduction and affect the validity of the monitoring. Optimized physiological conditions must be maintained for sound acquisition of data; vigilance must also be employed for the identification of technical artefacts or patient-related factors that may serve as artefacts or produce false positives.

Another cornerstone of effective IONM is interdisciplinary collaboration. Thus, anesthesiologists work closely with neurophysiologists, surgeons, and operating room staff for the interpretation of monitoring data and implementation of corrective action when necessary. For example, if MEPs suggest a decline in motor function during spinal surgery, the anesthesiologist may adjust anesthetic depth or the surgeon may alter his approach to reduce neural stress. In this way, real-time decision-making is a direct example of the critical role of teamwork in achieving success.

Anesthesiologists involved in the practice of IONM require training and education. Specialized knowledge and training include concepts of neural conduction, effects of anesthetic agents, and interpretation of monitoring data. Simulation-based training with continuing education would improve and enhance the competence of practitioners in this area to adequately address complexity in IONM. Despite all these advantages, IONM is not free of challenges. Technical factors that contribute to degrading accuracy of monitoring include signal interference and equipment malfunction. In addition, the cost of equipment used in IONM and the need for trained staff form some of the impediments to its widespread adoption. Overcoming these obstacles calls for collective efforts aimed at standardizing practice, lowering costs, and training and infrastructure investments.

Conclusion

Intraoperative neurological monitoring has dramatically changed the outcome of the surgery with real-time monitoring of the neural function. This will prevent the neural injuries while performing surgeries. Anesthesiologists play a critical role with the successful use of IONM.

References

1. Nuwer MR, Husain AM, Soto F (2022) Overview of intraoperative neuromonitoring. Handb Clin Neurol 186: 3-9.

2. Wong AK, Shils JL, Sani SB, Byrne RW (2022) Intraoperative Neuromonitoring. Neurol Clin 40(2): 375-389.

3. Lall RR, Hauptman JS, Munoz C, Cybulski GR, Koski T, et al. (2012) Intraoperative neurophysiological monitoring in spine surgery: indications, efficacy, and role of the preoperative checklist. Neurosurg Focus 33(5): E10.

4. Ali L, Jahangiri FR, Ali A, Belkhair S, Elalamy O, et al. (2021) Emerging Super-specialty of Neurology: Intraoperative Neurophysiological Monitoring (IONM) and Experience in Various Neurosurgeries at a Tertiary Care Hospital in Doha, Qatar. Cureus 13(12): e20432.

5. Minahan RE (2002) Intraoperative neuromonitoring. Neurologist 8(4): 209-226.

6. So VC, Poon CC (2016) Intraoperative neuromonitoring in major vascular surgery. Br J Anaesth 117(Suppl 2): ii13-ii25.

7. Guzzi G, Ricciuti RA, Della Torre A, Lo Turco E, Lavano A, et al. (2024) Intraoperative Neurophysiological Monitoring in Neurosurgery. J Clin Med 13(10): 2966.

8. Agarwal N, Shabani S, Huang J, Ben-Natan AR, Mummaneni PV (2022) Intraoperative Monitoring for Spinal Surgery. Neurol Clin 40(2): 269-281.

9. Gonzalez AA, Jeyanandarajan D, Hansen C, Zada G, Hsieh PC (2009) Intraoperative neurophysiological monitoring during spine surgery: a review. Neurosurg Focus 27(4): E6

10. Cofano F, Zenga F, Mammi M, Altieri R, Marengo N, et al. (2019) Intraoperative neurophysiological monitoring during spinal surgery: technical review in open and minimally invasive approaches. Neurosurg Rev 42(2): 297-307.

11. Rijs K, Klimek M, Scheltens-de Boer M, Biesheuvel K, Harhangi BS (2019) Intraoperative Neuromonitoring in Patients with Intramedullary Spinal Cord Tumor: A Systematic Review, Meta-Analysis, and Case Series. World Neurosurg 125: 498-510.

12. Tamkus A, Rice KS, Kim HL (2017) Intraoperative Neuromonitoring Alarms: Relationship of the Surgeon's Decision to Intervene (or Not) and Clinical Outcomes in a Subset of Spinal Surgical Patients with a New Postoperative Neurological Deficit. Neurodiagn J 57(4): 276-287.

13. Clark AJ, Ziewacz JE, Safaee M, Lau D, Lyon R, et al. (2013) Intraoperative neuromonitoring with MEPs and prediction of postoperative neurological deficits in patients undergoing surgery for cervical and cervicothoracic myelopathy. Neurosurg Focus 35(1): E7.

14. Iorio C, Koucheki R, Strantzas S, Vandenberk M, Lewis SJ, et al. (2023) Utility of intraoperative neurophysiological monitoring in detecting motor and sensory nerve injuries in pediatric high-grade spondylolisthesis. Spine J 23(12): 1920-1927.

15. Malik R, Linos D (2016) Intraoperative Neuromonitoring in Thyroid Surgery: A Systematic Review. World J Surg 40(8): 2051-2058.

16. Daniel JW, Botelho RV, Milano JB, Dantas FR, Onishi FJ, et al. (2018) Intraoperative Neurophysiological Monitoring in Spine Surgery: A Systematic Review and Meta-Analysis. Spine 43(16): 1154-1160.