



REVIEW

Intraoperative neuromonitoring and anesthesia considerations in peripheral nerve surgeries

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Background: Peripheral nerve surgery has evolved considerably with advances in microsurgical techniques and intraoperative neurophysiological monitoring aimed at preserving neural function and improving postoperative outcomes. Intraoperative neuromonitoring (IONM) provides real-time assessment of neural integrity, facilitates identification of functional neural tissue, and may reduce the risk of iatrogenic nerve injury. Commonly used modalities include free-running and triggered electromyography (EMG), somatosensory evoked potentials, motor evoked potentials, and nerve action potential (NAP) recordings. These techniques provide complementary information regarding neural function and are increasingly incorporated into complex peripheral nerve procedures.

Objective: This narrative review aims to review the current principles and clinical applications of IONM in peripheral nerve surgery, with particular emphasis on the interaction between anesthetic management and neurophysiological monitoring.

Discussion: This narrative review summarizes the principles and clinical applications of IONM in peripheral nerve surgery, with particular emphasis on anesthetic considerations. It examines the effects of anesthetic agents and techniques on commonly used monitoring modalities, strategies for optimizing intraoperative monitoring conditions, and approaches to troubleshooting changes in neurophysiological signals.

Conclusion: A comprehensive understanding of the interaction between anesthesia, surgery, and neurophysiological monitoring is essential for optimizing intraoperative decision-making, minimizing neurological complications, and supporting functional recovery following peripheral nerve procedures.

Keywords: peripheral nerve surgery, intraoperative neuromonitoring, nerve action potential, electromyography, peripheral nerve injury, anesthesia during neuromonitoring, nerve stimulation, nerve repair

Introduction

Peripheral nerve surgery comprises meticulous handling of neural structures with the aim of preserving or restoring its function. Intraoperative neuromonitoring (IONM) is used to help identify and assess neural structures and its integrity and help mitigate iatrogenic injury. Based on various physiological principles, each technique has its unique application in peripheral nerve surgery. IONM

allows real-time navigation and helps decision-making intraoperatively. It is commonly used in procedures for entrapment neuropathies, peripheral nerve tumors, traumatic injuries, and nerve grafting or transfers (1).

A multidisciplinary approach is imperative for the success of IONM during surgery. Anesthetic management plays a critical role, as the electrophysiological signals can be suppressed by various agents (2). Hence, physiological stability and careful selection of anesthetic agents are essential for the accuracy of monitoring.

The main objectives of neuromonitoring in peripheral nerve surgeries are:

- Identification of neural structures and their continuity
- Assessment of nerve conduction
- Detection of early signs of nerve injury
- Guidance during nerve repair and tumor resection
- To evaluate surgical outcomes during the procedure

Methodology

A narrative literature review was undertaken to identify and integrate available evidence regarding the use of neuromonitoring in peripheral nerve surgery and effects on anesthesia thereupon. The literature search was conducted using scientific databases PubMed/MEDLINE, Scopus, and Google Scholar. The search was conducted from October 2025 to March 2026, and relevant literature published from 2012 to 2025 was considered for inclusion.

The search strategy incorporated keywords and Medical Subject Headings (MeSH) terms related to peripheral nerve surgery and IONM. The principle search terms included “peripheral nerve surgery,” “peripheral nerve injury,” “IONM,” “nerve monitoring,” “nerve stimulation,” “electromyography,” “NAP,” “direct nerve stimulation,” “nerve repair,” and “anesthesia during neuromonitoring.” Appropriate synonyms and related terms were combined using Boolean operators AND and OR, and a search strategy was adapted for each database.

Modalities of intraoperative neuromonitoring

Nerve action potential (NAP)

Nerve action potential monitoring is mainly incorporated to determine axonal continuity. A bipolar probe is used for recording NAP. It involves electrical stimulation of a nerve by an electrode placed proximally, and the action potentials generated are recorded by the distal electrode. NAP signals recorded on the intact portion of the nerve serve as control potential. Electrodes are then sequentially moved distally along the injured area of the nerve, and the amplitude decreases or disappears across the lesion. Generally a duration of 0.05–0.1 ms (millisecond) and an intensity of 0.5–1 mA (milliampere) are employed; however, damaged nerves may need higher currents up to 25 mA (3). **Figure 1** shows the diagrammatic representation of the NAP signal. For lesions across which NAP is preserved, neurolysis is usually sufficient for treatment, whereas nerve grafting or repair is considered when action potential is not recorded. In a large study including 1736 patients undergoing surgery

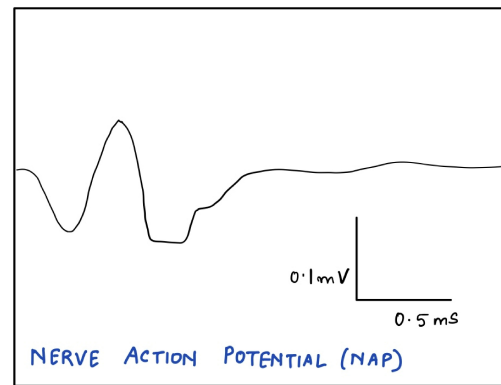


FIGURE 1 | Nerve action potential signal diagrammatic representation.

for lesions in continuity, grade 3 or better motor recovery was reported in 94.7% of patients when NAP was preserved across the lesion (4).

Triggered electromyography (EMG) and compound motor action potentials (CMAP)

This is one of the most commonly used techniques in peripheral nerve surgery. It measures electrical activity generated by muscles in response to nerve stimulation. Triggered electromyography (EMG) can be triggered or spontaneously recorded. It monitors the entire neuromuscular unit integrity, including the nerve, neuromuscular junction, and the muscle group. Compound motor action potential (CMAP) signals are of larger amplitude and easier to record. **Figure 2** provides a diagrammatic illustration of CMAP generation and waveform morphology. Free-running EMG from spontaneous electrical activity helps the surgeons to detect potential nerve irritation and prevent surgical injury. It records electrical activity by inserting a needle electrode directly into the muscle without any stimulation. Triggered EMG is useful in identifying motor nerves and is particularly beneficial in tumor surgery and reconstructive procedures (5). It involves stimulating nerves by monopolar electrodes and recording action potentials from the appropriate muscle group. Suzuki O et al. demonstrated beneficial results of using CMAP during Oberlin procedure in selecting the fascicle with the strongest amplitude lead to better outcomes (6).

Intraoperative recordings of triggered EMGs from the lumbar area are shown in **Figure 3**.

Clinical applications of IONM in peripheral nerve surgeries:

1. Peripheral nerve monitoring in spine surgeries
2. Traumatic nerve injury

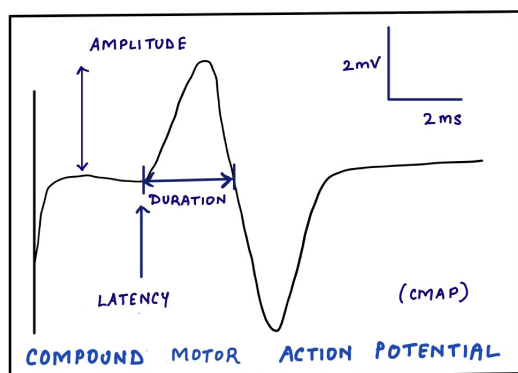


FIGURE 2 | Compound motor action potential (CMAP) diagrammatic representation.

3. Neuromas in continuity
4. Nerve transfer surgery
5. Nerve grafting and reconstruction
6. Peripheral nerve sheath tumors

Based on the real-time feedback, these modalities assist in surgical decision-making and selecting the appropriate treatment method, like neurolysis, resection, grafting, or reconstruction (7). However, IONM is bound by limitations such as operator expertise, technical challenges (electrode placement), interference by anesthetic drugs, and physiological conditions.

Anesthesia considerations in neuromonitoring

Anesthetic drugs produce a dose-dependent suppression of evoked potentials. Selecting an appropriate anesthetic technique is crucial to the success of IONM; to avoid interference with monitoring technique, preserve neural signal transmission, and maintain stable physiological conditions.

Intravenous anesthetic agents

Total intravenous anesthesia (TIVA) is the most preferred technique for various IONM methods. It has minimal effects on the action potentials and allows better control over depth of anesthesia. Propofol infusion with opioids like remifentanyl or fentanyl is commonly used (8). NAP, EMG, and evoked potentials are fairly maintained. The pharmacokinetic and pharmacodynamic profile of propofol makes it an excellent choice, as it allows rapid alterations in its sedative effects and impact over evoked potentials. However, motor evoked potential (MEP) and somatosensory evoked potential (SSEPs) can be suppressed with larger doses (8, 9). Target-controlled infusion of propofol and remifentanyl produces steady plasma concentrations, which permit titration of drug levels, and is the technique of choice

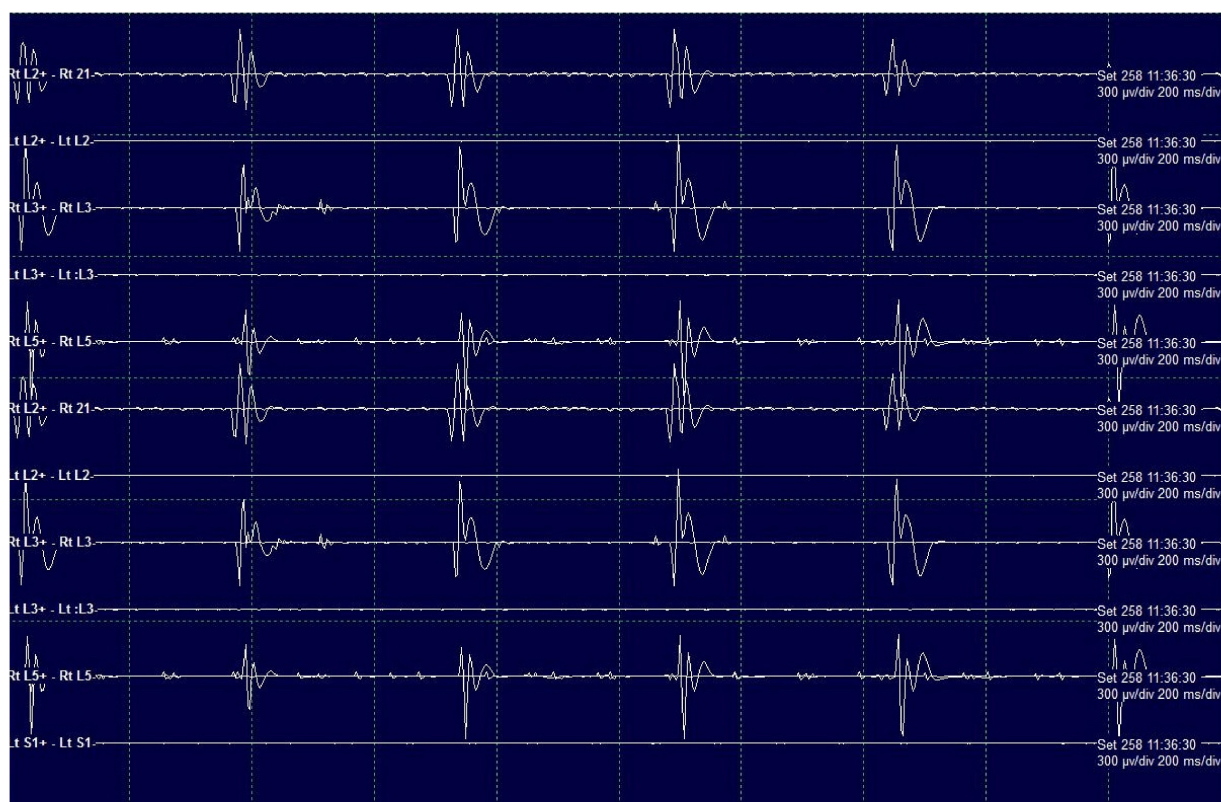


FIGURE 3 | Intraoperative Lumbar area triggered EMG signals.

for neuromonitoring. Ketamine can increase the amplitude of cortical SSEP and MEP. Schnoebel et al. demonstrated dose-dependent reduction in NAPs in dorsal horn neurones when ketamine was administered locally or intrathecally (10).

Dexmedetomidine has demonstrated variable effects on IONM. Low-dose infusions have a minimal effect, whereas higher infusions have been shown to depress transcranial MEPs.

Inhalational agents

Inhalation agents, including nitrous oxide (N₂O), have a profound impact on evoked potentials, mainly inhibiting synaptic transmission. Concentrations higher than one minimum alveolar concentration (MAC) produce dose-dependent reduction in signals. MEP signals are the most sensitive and need a balanced approach. It is better to avoid volatile agents during evoked potential monitoring. However, triggered EMG monitoring is carried out by stimulating the peripheral or cranial nerve directly, avoiding synaptic transmission, and hence volatile agents have minimal impact on them and hence can be used in peripheral nerve surgeries (11).

Neuromuscular blockers

CMAP and MEP signals are abolished by muscle relaxants and should be avoided (8). However, single bolus dose to assist endotracheal intubation can be used. The duration of action of the bolus dose should be taken into account before recording baseline signals. Sugammadex can be administered to reverse the effects of aminosteroidal drugs like rocuronium and vecuronium. Neuromonitoring with partial neuromuscular block can be done by monitoring the depth of paralysis using the train of four (TOF) technique, keeping the block restricted to one or two twitches. However, it reduces the amplitude of signals and may obscure significant neuronal injury; hence is better to avoid neuromuscular blockers (12).

Local anesthetics

Peripheral nerve blocks can interfere with neuromonitoring by blocking nerve conduction. NAPs and EMG signals are inhibited, and therefore regional anesthetic techniques should be avoided when neuromonitoring is planned.

Effects of various anesthetic agents on neuromonitoring modalities are summarized in [Table 1](#).

Physiological parameters

Several physiological factors impact monitoring, which can alter signals or mimic neuronal injury. Imbalance between

oxygen supply and metabolic demand in the neural tissue is the main cause for variations in signal measurements, which can interfere with monitoring.

Hypotension

Some procedures warrant the use of hypotensive techniques to minimize blood loss and provide a clean field for surgery. Hypotension can depress the amplitude and increase the latency of evoked potentials. As a result, IONM can indicate neural ischemia.

Hypoxemia can alter monitoring signals. Hematocrit levels less than 10–15% reduce oxygen-carrying capacity in the blood and can impact latency and amplitude.

Hypothermia induces vasoconstriction, which can impact neural perfusion. It also depresses nerve conduction velocities. It is recommended to maintain temperature within 2 degrees of baseline (13).

Hypocapnia: as a result of hyperventilation, it leads to vasoconstriction, leading to a reduction in oxygen delivery. This causes significant changes in patients with compromised vascular supply, posing a risk of injury.

Positioning: improper positioning can lead to peripheral nerve injuries and distortion of vascular anatomy. IONM measurements before and after positioning can help detect these changes and avoid permanent damage. Correction of position before surgery can be carried out.

Artefacts

Signal distortions can occur due to electrical interference from diathermy and other equipment and should be accounted for. Improper placement or dislodgement of electrodes and current leakage into the surrounding tissue can result in erroneous results.

TABLE 1 | Effects of various anesthetic agents on neuromonitoring modalities.

Anesthetic agent	NAP	EMG
Inhalational (MAC <1)	No effect	No effect
Inhalational (MAC >1)	Suppressed	May suppress
Propofol	No effect	No effect
Etomidate	No effect	No effect
Ketamine	Dose dependent suppression may occur	No effect
Opioids	No effect	No effect
Muscle relaxants	No effect	Suppresses
Benzodiazepines	No effect	No effect
Dexmedetomidine	No effect	No effect

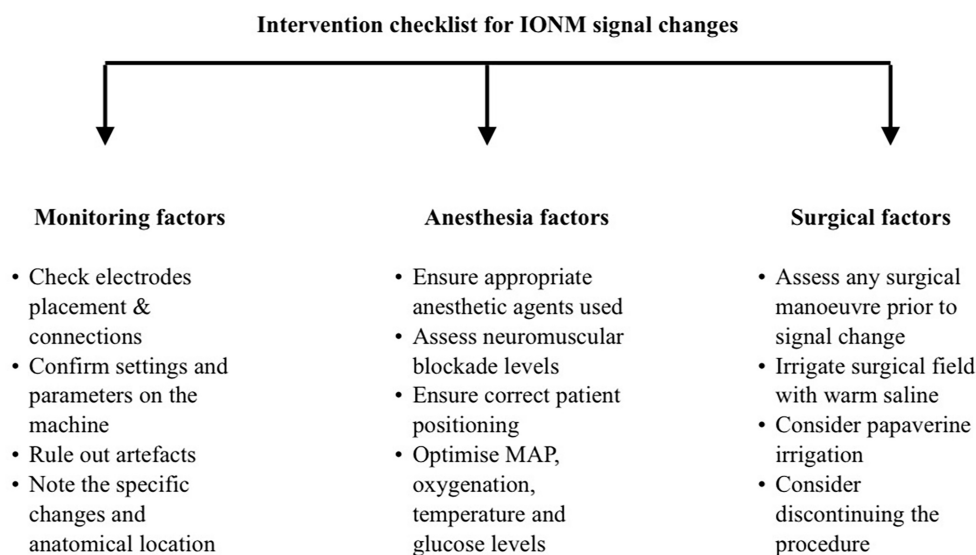


FIGURE 4 | Multidisciplinary checklist to review changes in neuromonitoring signals perioperatively.

Troubleshooting signal change

IONM involves a multidisciplinary approach and maintaining stable physiological parameters and appropriate anesthesia technique is essential to its success. Vigilance during monitoring helps identify the potential neural damage early and assists in decision making intraoperatively. Sudden complete loss of signals warrants immediately alerting the team and appropriate intervention. An increase in latency by 10 ms or decrease in amplitude by 50% is significant and should raise concerns. **Figure 4** represents a schematic multidisciplinary checklist to review and troubleshoot changes in neuromonitoring signals perioperatively.

Complications associated with IONM

Monitoring equipment should be checked in terms of electrical safety prior to use. In general, IONM is associated with a low risk of complications. Application and removal of dermal electrodes might cause bruising and skin damage and should be carefully applied. Rarely muscle soreness and tingling can occur post-monitoring. Seizure activity has also been reported with high-frequency electrical cortical stimulation (14).

This review has several limitations. The literature was identified and synthesized using a focused search strategy rather than formal systematic review methodology. Hence, possibility of selection bias and omission of relevant publications cannot be ruled out. Differences in neuromonitoring protocols, equipment, operator expertise, and interpretation of monitoring signals may also limit the generalizability of reported findings. Finally, publication and language bias cannot be excluded. These limitations should

be considered when interpreting the conclusions of this review and highlight the need for well-designed prospective studies to further define the clinical utility and outcome benefits of neuromonitoring in peripheral nerve surgery and the effects of various anesthetic agents.

Conclusion

IONM is a very beneficial technique for peripheral nerve surgeries, which provides real-time monitoring and navigation and assists in surgical decision-making. The success of it depends on a multidisciplinary team approach in identifying and correcting any aberrations in signals during surgery. Due to a lack of universal guidelines in using IONM, focus should be given to developing institutional protocols that can contribute to the success of this monitoring modality.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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