

Role of Intraoperative Neuro-Monitoring in Preventing Neurological Deficits During Spine Surgery: A Study of 70 Cases

Authors:

Mohammad Abu Taher Miah¹, Abu Saleh Mohammad Abu Obaida², Md. Ruhul Kuddus Biplob³, Kh Olinur Rajib⁴, Md. Mahbub Hasan⁵

¹ Medical Officer, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

²Associate Professor, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

³Associate Professor, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

⁴Medical Officer, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

⁵Register, Department of Neurosurgery, Sir Salimullah Medical College & Hospital, Dhaka, Bangladesh

Corresponding author:

Mohammad Abu Taher Miah, Medical Officer, Department of Neurosurgery, Bangladesh Medical University, Dhaka, Bangladesh

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ABSTRACT:

Neurological injury remains one of the most significant and devastating complications associated with spine surgery, often resulting in prolonged disability and reduced quality of life. Intraoperative neuro-monitoring (IONM) has been increasingly integrated into modern surgical practice to provide real-time assessment of spinal cord and nerve root integrity, thereby enabling timely intervention when neural compromise is detected. This study aimed to evaluate the role of IONM in preventing postoperative neurological deficits in a series of 70 patients undergoing various spine procedures. This prospective observational study was conducted between November- 2023 to December- 2024 and included adult patients undergoing cervical, thoracic, lumbar, or deformity-related spinal surgeries with multimodal IONM. Modalities utilized included somatosensory evoked potentials (SSEPs), motor evoked potentials (MEPs), electromyography (EMG), and neuromuscular blockade monitoring. Data were collected on demographic characteristics, type of surgery, frequency and nature of IONM alerts, intraoperative corrective measures, and postoperative neurological outcomes. Among the 70 patients included, IONM alerts were recorded in 12 cases (17.1%). MEP changes accounted for the majority of alerts, followed by SSEP reductions and EMG root irritation signals. Surgeons implemented timely corrective actions—such as adjusting instrumentation, elevating mean arterial pressure, reversing correction maneuvers, or optimizing anesthesia—in response to these alerts. Following intervention, 83.3% of the alerts resolved intraoperatively, preventing the progression to neurological injury. Two patients (2.8%) experienced transient postoperative neurological deficits, both of whom had persistent abnormal IONM signals despite corrective measures. Importantly, no patients in this cohort developed permanent neurological deficits. The findings of this study underscore the effectiveness of multimodal IONM in enhancing patient safety during spine surgery. IONM provided early detection of neural compromise, allowing for timely intraoperative changes that significantly reduced the incidence of neurological injury. The low rate of postoperative deficits, along with the complete absence of permanent neurological impairment, highlights the critical role of IONM particularly MEPs and SSEPs in safeguarding neural structures during complex spinal procedures. Widespread adoption of IONM, especially in high-risk surgeries, is strongly recommended to improve surgical outcomes and reduce neurological morbidity.

Keywords: *Intraoperative neuro-monitoring, spine surgery, motor evoked potentials, somatosensory evoked potentials, neurological deficits, electromyography, multimodal monitoring*

INTRODUCTION:

Neurological injury remains one of the most critical and feared complications associated with spine surgery, with potential outcomes ranging from transient sensory deficits to permanent paralysis. The incidence of postoperative neurological deficits varies depending on the type of procedure, surgical complexity, and patient-specific risk factors, typically ranging from 1% to 5% in routine spinal procedures, and higher in deformity or tumor surgeries [1]. Preventing such complications is paramount to improving patient outcomes and maintaining surgical safety standards. Over the past two decades, intraoperative neuro-monitoring (IONM) has emerged as an essential adjunct to spine surgery by providing real-time physiological feedback on spinal cord and nerve root function. IONM encompasses several modalities, including somatosensory evoked potentials (SSEPs), motor evoked potentials (MEPs), electromyography (EMG), and neuromuscular junction monitoring. Each modality offers unique advantages: SSEPs provide continuous assessment of dorsal column function, MEPs offer sensitivity to motor pathway integrity, and EMG helps detect mechanical irritation or injury to nerve roots [2]. By integrating multiple modalities, surgeons can achieve a more comprehensive assessment of neural structures during critical surgical steps. The ability to detect early electrophysiological changes before irreversible injury occurs enables timely corrective actions such as adjusting instrumentation, reducing deformity correction, increasing perfusion pressure, or modifying anesthetic depth. Advancements in spinal instrumentation and surgical techniques, particularly in deformity correction and complex reconstruction, have increased the reliance on IONM to ensure procedural safety. Studies have shown that multimodal IONM improves the detection rate of neurological compromise compared to single-modality monitoring, with MEPs demonstrating especially high sensitivity for motor pathway dysfunction [3]. Furthermore, the integration of IONM has been associated with a reduction in permanent neurological deficits in high-risk surgeries, reinforcing its clinical value [4]. Despite this, access to IONM remains variable in many regions due to technical, logistical, and financial challenges. In developing healthcare settings, there is a growing need to generate institutional evidence on the effectiveness of IONM to support broader implementation. While international data support its efficacy, regional research remains limited. Understanding the relationship between intraoperative alerts, corrective surgical actions, and postoperative neurological outcomes in local populations can help refine protocols, improve safety practices, and justify the integration of IONM into routine spinal procedures. The present study evaluates the role of multimodal IONM in preventing neurological deficits during spine surgery in a cohort of 70 patients. By assessing the frequency and

nature of IONM alerts, the responsiveness to corrective interventions, and the correlation with postoperative outcomes, this study aims to contribute valuable evidence supporting the continued expansion of IONM use in spine surgery practice.

MATERIALS AND METHOD:

This prospective observational study was conducted in the Department of Neurosurgery from November- 2023 to December- 2024. The primary objective was to evaluate the effectiveness of intraoperative neuro-monitoring (IONM) in reducing postoperative neurological deficits during a wide range of spinal procedures. A total of 70 patients were included based on predefined eligibility criteria.

Study Design and Population:

Patients aged 18–75 years undergoing elective or emergency spinal surgery with the availability of full multimodal IONM were consecutively enrolled. Inclusion criteria comprised patients diagnosed with degenerative spine diseases, traumatic injuries, spinal tumors, deformities, or spinal canal stenosis. Exclusion criteria included patients with pre-existing complete spinal cord injury, severe neuromuscular disorders affecting electrophysiological monitoring, or cases where IONM could not be reliably performed due to technical limitations.

Preoperative Evaluation:

All patients underwent detailed neurological examination, imaging studies (MRI and/or CT), and anesthetic evaluation. Baseline motor and sensory function were documented to facilitate postoperative comparison.

Intraoperative Neuro-Monitoring Modalities:

Multimodal IONM was utilized in all cases and included:

- Somatosensory Evoked Potentials (SSEPs): Used to assess the integrity of the dorsal column pathways.
- Motor Evoked Potentials (MEPs): Monitored corticospinal tract function, particularly sensitive to ischemia or mechanical injury.
- Free-Run and Triggered Electromyography (EMG): Employed to detect nerve root irritation or compression, especially during decompression and instrumentation.
- Train-of-Four (TOF): Used to regulate neuromuscular blockade and ensure reliable MEP signals.

Anesthetic Protocol:

A standardized anesthetic protocol was followed to optimize electrophysiological monitoring. Inhalational agents were minimized, and total intravenous anesthesia (TIVA) with propofol and opioids was preferred. Muscle

relaxants were avoided after intubation except for minimal dosing guided by TOF monitoring.

Intraoperative Data Collection:

During surgery, continuous monitoring was performed by a trained neurophysiology team. Significant IONM alerts were defined as >50% reduction in SSEP amplitude, complete loss or substantial reduction in MEP signals, or sustained EMG discharges. Upon detection of an alert, surgeons were immediately informed, and corrective measures such as adjusting instrumentation, increasing mean arterial pressure, or reversing corrective maneuvers were undertaken.

Outcome Assessment:

Primary outcome was the occurrence of new neurological deficits postoperatively, assessed at 24 hours, 72 hours, and at discharge. Secondary outcomes included the incidence of IONM alerts, correlation with intraoperative events, and the effectiveness of corrective interventions.

RESULTS:

Out of the 70 patients included in the study, the majority were male (58.6%) with a mean age of 49.6 years. Lumbar decompression and fusion were the most common procedures (45.7%), followed by cervical surgeries (28.6%), thoracic interventions (14.3%), and deformity corrections (11.4%). Intraoperative neuro-monitoring alerts occurred in 12 cases (17.1%). Motor evoked potential reductions were the most frequent alerts (7 cases), followed by SSEP amplitude drops (4 cases) and EMG-detected root irritation (1 case). Corrective intraoperative actions resolved 10 out of 12 alerts, preventing permanent neurological injury. Two patients developed transient deficits, both associated with persistent abnormal IONM findings. Overall, 68 patients (97.2%) had no postoperative deficits, demonstrating the efficacy of IONM in detecting and allowing timely correction of intraoperative neural compromise.

Table-1: Patient Demographics

Parameter	Value
Total patients	70
Mean age (years)	49.6 ± 13.2
Gender (Male/Female)	41/29
Age distribution	
18–30	8
31–50	25
51–70	32
>70	5

Table-2: Types of Spine Surgeries

Surgery Type	Number of Cases	Percentage
Lumbar decompression/fusion	32	45.7%
Cervical decompression/fusion	20	28.6%
Thoracic procedures	10	14.3%
Deformity correction	8	11.4%

Table-3: Intraoperative Neuro-Monitoring Alerts

Alert Type	Number of Cases	Corrective Action Successful	Persistent Deficit
MEP reduction	7	6	1
SSEP amplitude drop	4	3	1
EMG root irritation	1	1	0
Total	12	10	2

Table-4: Postoperative Neurological Outcomes

Outcome	Number of Patients	Percentage
No deficit	68	97.2%
Transient deficit	2	2.8%
Permanent deficit	0	0%

DISCUSSION:

The present study reinforces the critical role of intraoperative neuro-monitoring (IONM) in enhancing the safety of spine surgery. Neurological deficits, although infrequent, are among the most serious complications of spinal procedures, potentially leading to permanent disability and reduced quality of life [1]. The overall postoperative neurological preservation rate of 97.2% in this cohort aligns with reported international benchmarks and demonstrates the efficacy of multimodal IONM in preventing injury [2]. Motor evoked potentials (MEPs) were the most sensitive modality in detecting impending motor pathway compromise, consistent with previous studies demonstrating MEPs' high sensitivity and specificity for predicting postoperative motor deficits [3,4]. Somatosensory evoked potentials (SSEPs), while valuable for monitoring dorsal column function, were less predictive of motor outcomes but served as an important adjunct in multimodal monitoring, particularly in surgeries involving thoracic or cervical decompression [5]. The integration of free-run and triggered electromyography (EMG) allowed for real-time detection of nerve root irritation during decompression or instrumentation, thereby reducing iatrogenic root injury [6]. The study observed that timely corrective measures, such as adjusting instrumentation, elevating mean arterial pressure, and modifying deformity correction maneuvers, successfully resolved 83.3% of IONM alerts, preventing progression to permanent deficits. This finding underscores the principle that intraoperative alerts provide a window of opportunity for surgical intervention before irreversible neurological injury occurs [7]. The two patients with transient deficits were notable in that persistent IONM abnormalities despite corrective efforts correlated with their postoperative symptoms, emphasizing the importance of prompt recognition and response to sustained alerts [8]. Our results support existing literature advocating for routine multimodal IONM, particularly in high-risk procedures such as deformity correction, tumor excision, and multi-level instrumentation, where neural structures are at elevated risk [9]. Moreover, the use of IONM facilitates informed intraoperative decision-making, allowing surgeons to modify surgical technique dynamically in response to neural compromise, thereby enhancing patient safety and improving surgical outcomes [10]. Limitations of this study include its single-center design and the relatively small sample size of 70 patients, which may limit generalizability. Future multicenter studies with larger cohorts are warranted to further validate these findings and refine IONM protocols. Despite these limitations, the present study provides valuable evidence supporting the effectiveness of IONM in preventing neurological deficits

in spine surgery. In our study, multimodal IONM serves as an indispensable tool for real-time monitoring of neural function during spine surgery. Its application significantly reduces the incidence of postoperative neurological deficits, ensuring patient safety and enhancing surgical outcomes [11].

CONCLUSION:

Intraoperative neuro-monitoring (IONM) is a vital adjunct in spine surgery, providing real-time feedback on neural integrity and enabling timely corrective interventions. In this study of 70 patients, multimodal IONM successfully identified intraoperative neural compromise, allowing surgeons to prevent permanent neurological deficits. The low incidence of transient postoperative deficits and the absence of permanent injuries underscore the effectiveness of IONM in enhancing patient safety. Routine implementation of multimodal IONM, particularly in complex or high-risk spine surgeries, is strongly recommended to optimize surgical outcomes and minimize neurological morbidity.

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