Utility of Intraoperative Neuromonitoring (IONM) in Tertiary Care Center - Our experiences

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Introduction: All spine and neurosurgical procedures carry an inadvertent risk of injury to neural structures and pathways that may result in a postoperative neurological deficit. Stagnara wake-up test and postoperative ankle clonus monitor gross motor function and need emergence from anesthesia. These are not real-time hence substantial time would have passed before detecting injury. IONM is real-time monitoring of neural structure and pathways to provide a window of opportunity to revert inadvertent neurological injury during surgery. Various types of neurophysiological monitoring include Somatosensory Evoked Potentials (SSEPs), Motor Evoked Potentials (MEPs), and Electromyography (EMG) i.e spontaneous and triggered. This paper shares brief experiences and assesses the role and utility of IONM in the spine and cranial surgeries.

Methods: This is a retrospective study carried out between April 2020 and March 2022 at Hospital and Rehabilitation Centre for Disabled Children (HRDC) and B and B Hospital. Demographic details, diagnosis, pre and post-operative neurological status, type of surgery, duration of surgery, and number of significant alerts during surgery were reviewed.

Results:

We had 18 patients (n=18) in whom IONM was used. 12 patients were operated on by the orthopedic spine team and 6 patients by the neurosurgery team. The median age of the patient was 19 years (IQR: 46.25). The most common indication for IONM was deformity correction

(Adolescent Idiopathic Scoliosis/AIS). Three cases showed a single burst pattern on Spontaneous Electromyography (sEMG) during awl use, which was not clinically significant. One case showed loss of MEP signal on the left Tibialis Anterior muscle, which was due to loss of electrode attachment. No true alerts were recorded in our study group. All patients were neurologically intact postoperatively. There were no complications related to Transcranial EMG (TcEMG) or positioning.

Conclusion: TcMEP and EMG are safe and efficacious. IONM improves the safety and confidence of operating surgery by providing real-time assessment of neural structures at risk. For IONM to be effective, coordination between neurophysiologist/technician, anesthesiologist, and surgeon is required.

Keywords: deformity correction, intraoperative, IONM, neuromonitoring, spine surgery, TcEM

All spine and neurosurgical procedures carry an inadvertent risk of injury to neural structures and pathways that may result in a postoperative neurological deficit.[1] Neural injury occurs during the distraction, deformity correction, screw placement, tumor resection, or due to vascular insult. Deformity correction, tumor dissection, revision surgeries, and degenerative cases carry a high risk of neurological injury. Stagnara wake-up test and postoperative ankle clonus monitor gross motor function and need emergence from anesthesia.[2, 3] These are not real-time hence substantial time would have passed before detecting injury. IONM is real-time monitoring of neural structure and pathways to provide a window of opportunity to revert inadvertent neurological injury that occurred during surgery.[4] Various types of neurophysiological monitoring include Somatosensory Evoked Potentials (SSEPs), Motor Evoked Potentials (MEPs), and Electromyography (EMG) i.e spontaneous and triggered. SSEPs assess the sensory (dorsal column) pathways throughout the surgery by stimulating peripheral nerves. MEPs assess the motor (corticospinal tract) pathways by stimulating scalp electrodes and providing a real-time assessment of motor function. Spontaneous EMG (sEMG) and triggered EMG (tEMG) are used to assess the nerve root functions and integrity of the pedicle wall. [5] This paper shares brief experiences and assesses the role and utility of IONM in the spine and cranial surgeries.

Methodology

All cases in which IONM was used from April 2020 - March 2022 at

Hospital and Rehabilitation Centre for Disabled Children (HRDC) and B and B Hospital were retrospectively reviewed. Our study included 18 patients: 12 operated by the orthopedic spine team and 6 operated by the neurosurgery team. Patients with pre-operative neuro deficit (motor power <3 as per MRC grading) were excluded. All surgeries were performed with Transcranial Motor Evoked Potential (TcMEP) and EMG monitoring under the Total Intravenous Anesthesia (TIVA) protocol with propofol and fentanyl. A single dose of muscle relaxant was used at the time of induction. A trained technician performed IONM. Demographic details, diagnosis, pre and post-operative neurological status, type of surgery, duration of surgery, and number of significant alerts during surgery were reviewed.

Stagnara wake-up test was explained to older children (Age >10) and adult patients before induction of anesthesia.

IONM Technique

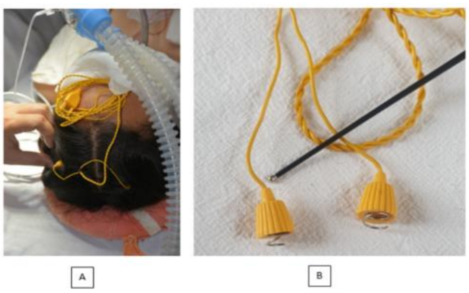


Figure 1: A: Corkscrew scalp electrode for TcMEP, B: Corkscrew Electrode

TcMEP and EMG were used at our

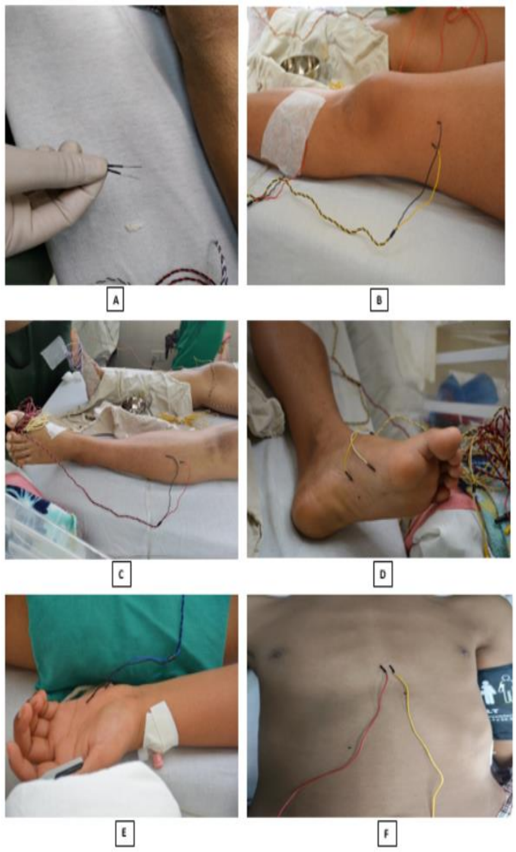


Figure 2: Intramuscular needle electrodes placed over the peripheral muscle group

A: Needle electrode, B: Vastus Lateralis (VL), C: Tibialis Anterior (TA), D: Abductor hallucis (AH), E: Abductor Digiti Minimi (ADM), F: Sternum for Earthing

Muscles routinely used were Vastus lateralis (VL), Tibialis Anterior (TA), and Abductor hallucis (AH). One muscle group above the level of surgery was used as a control group, usually the hand muscles: the thenar group (Abductor pollicis brevis) /the hypothenar group (abductor digiti minimi).

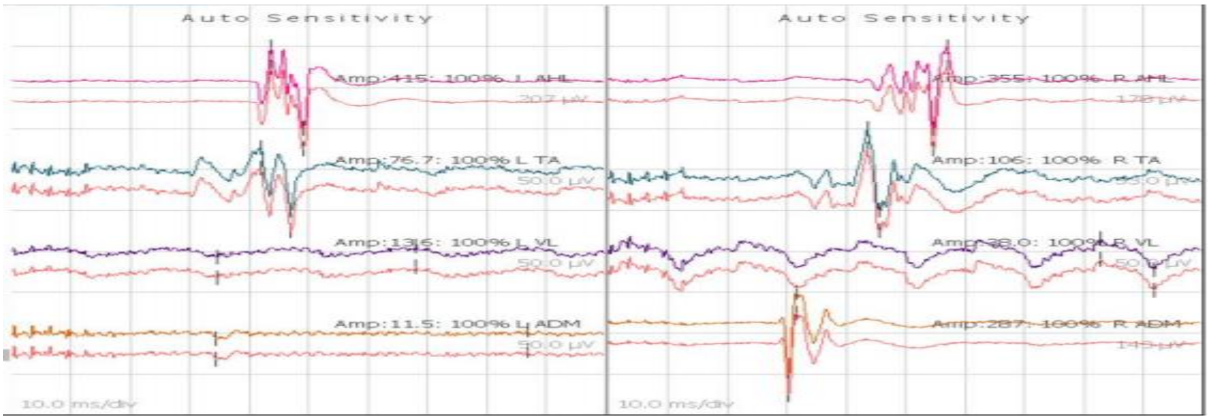
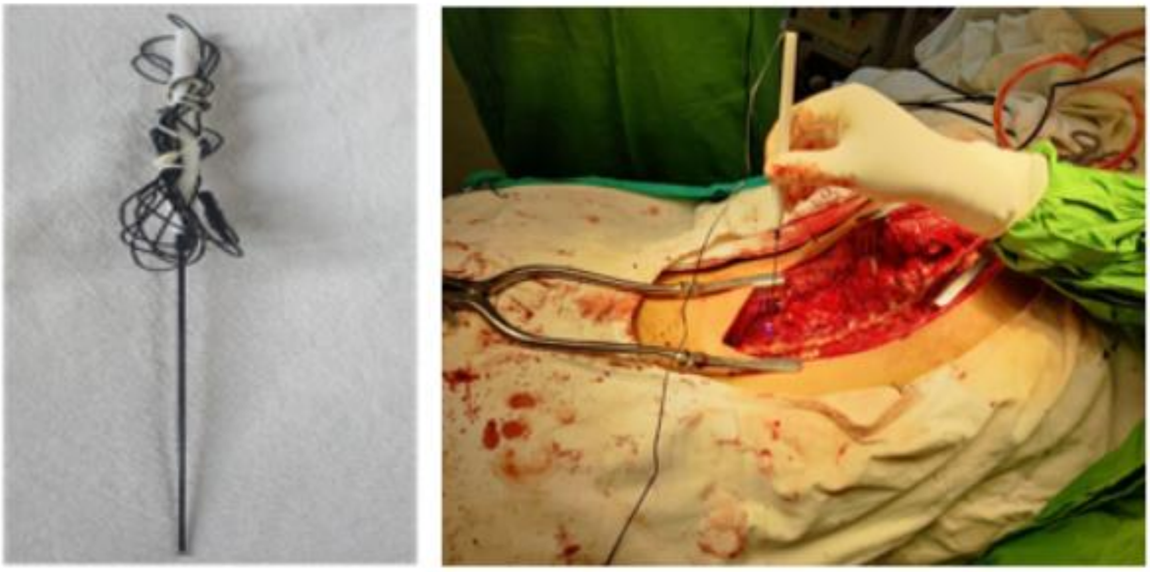


Figure 3: Baseline MEP before Skin Incision Triggered EMG (tEMG) was done by a monopolar electrode with increasing current intensity applied to the center of the head of the tulip.



A

B

Figure 4: A: Monopolar Electrode used for tEMG B: Monopolar electrode applied to the center of the head of the tulip

institute. TcMEP was used in all cases along with spontaneous Electromyography (sEMG). Triggered Electromyography (tEMG) was used in cases where instrumentation was done. TcMEP was elicited by transcranial stimulation, using two corkscrew surface electrodes placed over the scalp (10-20 international system) [6] as shown in **Figure 1** and recorded from intramuscular electrodes placed over the peripheral muscle group as shown in **Figure 2.**

Baseline MEP recordings **(Figure 3)** were obtained after the patient was in a prone position just before the skin incision.MEP was then repeated after exposure, instrumentation, before and after corrective surgical aneuver/decompression/excision, and just before closure. [7]

An "alert" was called in by a technician if there was a decrease in amplitude by 50% or more or a 100V increase in threshold or latency prolongation >10% as compared to baseline or complete absence of signal in one or more electrodes. IONM alert checklist was followed in case of any alert.[8]

Statistical Analysis

All data were entered in a google excel sheet and descriptive analysis was done for quantitative variables.

Results

We had 18 patients (n=18) in whom IONM was used.12 patients were operated on by the orthopedic spine team and 6 patients by the neurosurgery team. Demographic details are listed in **Table 1.**

Orthopedic spine surgeons used IONM exclusively for pediatric deformity correction cases whereas neurosurgeons used it for tumor, degenerative and trauma cases. The most common indication for IONM was deformity correction. Adolescent Idiopathic Scoliosis (AIS) was the most common deformity. Neurosurgeons used IONM for intradural extramedullary spinal tumor (IDEM), parietal lobe glioma, and degenerative spondylotic cervical myelopathy.

Three cases showed a single burst pattern on spontaneous EMG during awl use,

Characteristics	**Frequency (n)**
Median Age (years)	19 (IQR = 46.25)
Sex (N=18)	
Male (M)	7
Female (F)	11
Diagnosis (N= 18)	
Deformity	12
Adolescent Idiopathic Scoliosis	8
Post TB Kyphosis	1
Congenital Scoliosis	2
Neuromuscular Scoliosis	1
Trauma	2
Tumor	3
Spinal Tumor	1
Brain Tumor	2
Degenerative	1

Table 3: IQR= InterQuartile Range (Q3-Q1)

which was not clinically significant. One case showed loss of MEP signal on the left tibialis anterior muscle, which was due to loss of electrode attachment. No true alerts were recorded in our study group. All patients were neurologically intact postoperatively. There were no complications related to TcEMG like scalp burn, tongue/lip laceration, seizure, or any other complications.[9]

Discussion

In our study of 18 patients, mostly pediatric deformity correction cases, there were no reports of complications related to TcEMG or prone positioning. IONM helps prevent perioperative nerve injury due to excess pressure and torsion of the neck or limbs. Brachial plexopathies is a common complication with a risk as high as 6.2 % according to Labrom et al.[10]TcEMG use can result in lip/tongue lacerations or seizures and cardiac arrhythmias.[11] In all cases, eyes were taped shut and padded, all bony eminences were well padded, and a bite block was wedged between the teeth to prevent injury to the oral cavity.

IONM setup took an average of 20 mins for all cases, which added to the anesthesia time the patient is subjected to. TcMEP is highly sensitive to inhalational agents and muscle relaxants.[12] Anesthesiologists faced difficulties maintaining the anesthesia without muscle relaxants. Even though remifentanil is the drug of choice for TIVA, the anesthesiologist had to contain it with fentanyl, due to the unavailability of remifentanil.[13] Maintaining Mean arterial pressure (MAP) >60 mm of Hg is essential during surgery to avoid ischemia to the spinal cord. We aim for MAP >85-90mm of Hg during the corrective procedure and cord handling.[5]

Intraoperative monitoring was done by technicians with a brief training on IONM and not neurophysiologist. We faced a lot of problems initially with false alerts, caused by artifacts and detachment of electrodes. Constant alteration of anesthetic depth was one of the major challenges we faced. With subsequent training and experiences, things were better and smooth with improved coordination among anesthesiologists, surgeons, and neuromonitoring technicians.[4] We had three cases where a burst pattern was seen in spontaneous EMG. These were not significant alerts. Hence no alert was reported in our series of cases. In case of an alert, we follow the IONM alert checklist.[8]

Before the use of IONM, we relied upon the stagnara wake-up test and postoperative clonus to assess the neurological status. Still, these tests have a role in monitoring the neurological status intraoperative.[2] Wake-up tests are implemented when a patient has persistent alerts despite corrective measures. We had no patients subjected to these tests.

We used MEP and EMG to monitor neurological status. We have no experience using SSEPs.As shown by Clark et al study[14], TcEMG had a sensitivity of 75%, and specificity of 98%. Even though multimodality IONM has high sensitivity (93%) and specificity (99.1%)[15], MEPs alone can be used to assess spinal cord function. Our brief experience of 2 years with IONM made us more confident and secure in terms of achieving more correction of deformity, excising tumors, and putting pedicle screws in difficult/altered anatomy of the pedicle. IONM can be safely used for all high-risk orthopedic and neurosurgical procedures.

IONM was mostly used in deformity correction and tumor resection at our institute. It can be an important adjunct surgical service not only to orthopedics and neurosurgery departments but can be extended to other specialties like Otorhinolaryngology, Ophthalmology, and Cardiovascular Surgery. Wojtczak et al reported an increase in identification of recurrent laryngeal nerve and decreased injury rate with the use of IONM during thyroidectomy.[16]

IONM use is very limited in our country. Cost, lack of awareness, limited resources, and unavailability of trained personnel for use is one of the major reasons for its limited use. Guiroy et al in their cross-sectional study among members of the AO Spine Latin American group concluded that despite 68% of spine surgeons believing IONM is indispensable for complex spine surgery, the cost was the main barrier to its use. [17]

Limitations of the study

This was a retrospective descriptive study and does not involve using multimodal IONM. The sample size was small as we are beginning to utilize IONM and does not represent all types of deformities. Further study with larger sample size and heterogeneity of cases is advisable.

Conclusion

Intraoperative Neuromonitoring (IONM) is evolving rapidly with the potential to greatly improve the safety of surgery. TcMEP and EMG are safe and efficacious. IONM improves the safety and confidence of operating surgery by providing real-time assessment of neural structures at risk. For IONM to be effective, coordination between neurophysiologist/technician, anesthesiologist, and surgeon is required. It can be used for a wide variety of cases, more so in high-risk cases of postoperative deficit. We believe deformity correction and tumor cases should be ideally done with IONM. Multimodality IONM is more sensitive and specific. IONM has medico-legal importance, which needs validation with a larger-scale study. Availability and cost issues remain a barrier to its use in developing countries.

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