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Intraoperative Neuromonitoring in Predicting Neurological Deficits in Patients with Intramedullary Lesions in a Tertiary Care Center in Nepal

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ABSTRACT

Introduction
Intramedullary spinal cord lesions (IMSCL) constitute 20%–30% of all spinal cord lesions. There is still uncertainty regarding the usefulness of intraoperative neuromonitoring (IONM) during spinal surgery. The purpose of this study is to determine the effectiveness of IONM in patients undergoing intramedullary spinal surgery.

Methods
Twenty-three patients who underwent surgery at the Department of Neurosurgery, Tribhuvan University Teaching Hospital from January 2017 to December 2020 were included. Somatosensory evoked potential, transcranial motor evoked potentials and electromyography were recorded. Patients were divided into three groups based on IONM parameters: 1. one with no drop 2. one with a decrease and a recovery during surgery, and 3. one with a decrease but no recovery. The duration of follow-up was six months.

Results
Neurological improvement was noted in 14 patients, stable in 4, and worse in 5. Out of 14 patients with clinical improvement, 9 had no decrease in IONM, while 5 had a temporary decrease. Among 4 patients whose postoperative status remained unchanged, 2 had no decrease in IONM, while one had a temporary decrease and one has a sustained decrease. Among 5 patients who deteriorated postoperatively, 1 had no decrease in IONM, and 4 had a decrease without recovery. During surgery, patients who demonstrated monitoring alterations but reverted to baseline had better neurological outcomes than those who did not (p=0.045).

Conclusion
Our findings support that IONM is an effective tool for the safe resection of IMSCL. Further multi-centric larger studies are recommended to gain more insight into IONM.

Keywords
Electromyography, intramedullary spinal cord lesions, intraoperative neuromonitoring, somatosensory evoked potential, transcranial motor evoked potential

INTRODUCTION

Intramedullary spinal cord lesions (IMSCL) constitute approximately 20%–30% of spinal cord lesions.[1-2] Types of lesions in decreasing order of frequency are ependymomas, astrocytomas, hemangioblastomas, and lipomas. The presenting symptoms include back and radicular or neuropathic pain, motor disturbances, sensory symptoms, and sphincter disturbances.[3-6] Although surgery is the mainstay of treatment, risks and benefits need a careful balance (radical surgery vs conservative surgery in terms of neurological complications).[7-8]

Intraoperative neuromonitoring (IONM) has been in use for the last several decades all over the world. Techniques used include somatosensory evoked potentials (SSEPs); motor-evoked potentials (MEPs); and spontaneous and triggered electromyography (EMG).[9-10] Controversy still exists regarding the usefulness of this technique for the safe resection of tumors.[7,11] No studies regarding its use have been carried out in Nepal. The purpose of this study was to assess the effectiveness of IONM in increasing the safety of IMSCL surgery.

METHODS

We retrieved the information from our prospectively collected data of consecutive 23 patients operated on for intramedullary lesions in the Department of Neurosurgery, Tribhuvan University Teaching Hospital from January 2017 to December 2020. All patients undergoing microsurgery with IONM with at least six months follow up were included.

Clinical (signs and symptoms referable to neurological impairment) and radiological data, intraoperative findings, and IONM status were documented. The modified McCormick scale (ranging from I to V) was used to assess the neurological status of the patient (Table 1).[12] At six months, the neurological status was classified as improved, stable or worse.

Table 1. Modified McCormick classification[12]

Grade	Description
I	Normal exam
II	Deficit induced a non-motor functional impairment
III	Presence of motor deficit affecting function. Mild-to-moderate gait difficulty. Severe pain or dysesthetic syndrome affects a patient's quality of life. The patient still functions and ambulates independently
IV	More severe neurological deficit. Requires care/brace for ambulation or significant bilateral upper extremity impairment, May or may not function independently
V	Severe deficits. Require wheelchair or cate/brace with bilateral upper extremity impairment. Usually not independent

All the patients were operated in prone position and SSEP, tcMEP and EMG were performed during the surgery. Standard preoperative and intraoperative techniques were used to monitor these parameters. The monitoring system used in our institute was of Medtronics NIM Eclipse SD nerve monitoring system. The surgical procedure involved a laminectomy or laminoplasty, midline myelotomy, and safe maximal resection of the tumor with microsurgical technique. Figure 1 shows a representative patient from our series. We described the following variables in the patient population: age, sex, presenting feature, histology, modified McCormick classification, location, and postoperative outcome.

Based on IONM parameters, patients were divided into three groups: one with no drop in IONM parameters, one with a decrease and a recovery during surgery, and one with a decrease

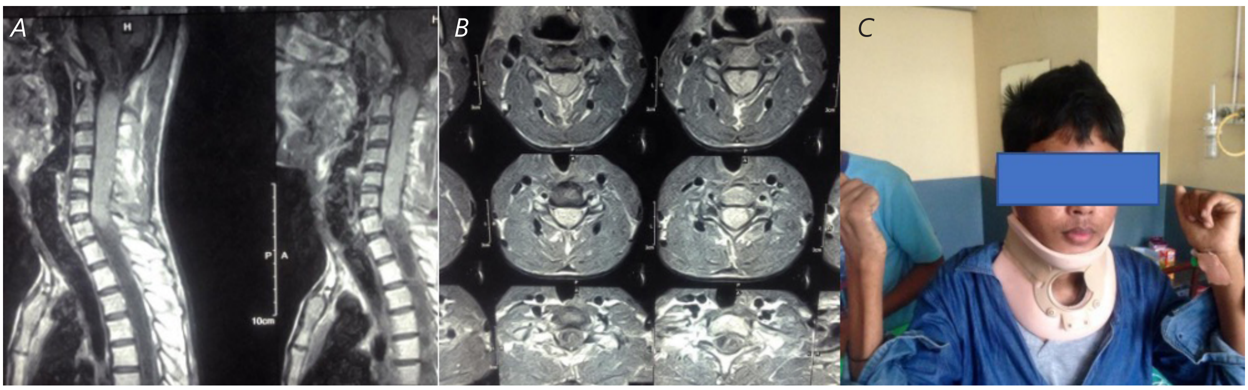

Figure 1. Post-contrast sagittal (A), and axial (B) MRI of a 25 yr old male patient showing an intramedullary extending from C2-C6 level. The patient (C) at six months after surgery with significant improvement in neurological outcome. The histopathological diagnosis was an ependymoma

Table 2. Frequency of intramedullary lesions

Histological types	Number
Astrocytoma	7
Ependymoma	7
Myxopapillary ependymoma	5
Ancient Schwannoma	1
Neurocysticercosis	1
Lipoma	1
Tuberculoma	1

but no recovery. The demographic and clinical characteristics, intraoperative findings, and IONM parameters were reported using medians or means or proportions. Statistical analyses were performed using SPSS Statistics version 22, IBM, Armonk, New York, USA. Chi-squared test was used to define the association between two categorical variables and $p < 0.05$ was considered significant.

RESULTS

Twenty-three patients were operated on for IMSCL during the study period. Of these patients, seven were located in the cervical, eight were located in the thoracic region, and eight were located in the lumbar region. The mean age was 42.8 years with a range from eight to 70 years. Preoperative Modified McCormick was I in four patients (17.5%), II in 12 (52.1%), III in six (26%), and IV in one patient (4.4%).

The histological findings in these intramedullary lesions are shown in Table 2. Astrocytoma (7) was the commenst tumor followed by ependymoma. Complete excision was achieved in 15(65.2%) patients and subtotal excision/biopsy was done in eight patients. The tumor extending up to two levels was in 17 (74.0%) patients and three or more in six (26.0%) patients.

The presenting symptoms include non-painful sensory changes (14 cases, 61%) and pain (13 cases, 56%), and motor deficits (eight cases, 35%). Sphincter and gait symptoms were other infrequent symptoms and two patients were asymptomatic. There were two occurrences of postoperative complications (8.7%), one of which involved a CSF fluid fistula and the other of which had a wound infection. In one patient, tumor progression was detected at six months.

In six months, neurological status improved in 14 patients (60.8%), stable in four (17.3%) patients, and worse in five (21.7%). Patients were also divided into three groups based on IONM parameters. Among 23 patients, 12 (52.1%) did not show any intraoperative signal change, while 11 (47.9%) showed a decreased signal, six patients (26%) with recovery, and five (21.9%) without recovery. Of 14 patients with clinical improvement, nine had no decrease in IONM, while five had a temporary decrease. Among four patients whose postoperative status remained unchanged, two had no decrease in IONM, while one had a temporary decrease and one has a sustained decrease. Among five patients who deteriorated postoperatively, one had no decrease in IONM, and four had a decrease without recovery (Table 3).

We compared patient outcomes with IONM parameters (Table 4). Individuals with a change in a

Table 3. Correlation of intraoperative neuromonitoring parameters with clinical outcome

IONM parameters	Clinical outcome			
	Improvement	Stable	Worse	Total
No decrease	9	2	1	12 (52.1)
Decrease with recovery	5	1	0	6 (26)
Decrease without recovery	0	1	4	5 (21.9)
Total	14 (60.8)	4 (17.3)	5 (21.7)	23

Table 4. Correlation of IONM change and IONM improvement with outcome

Factors	Clinical outcome				p-value
	Improvement	Stable	Worse	Total	
IONM change					
Yes	5	2	4	11	0.02
No	9	2	1	12	
IONM improvement					
Yes	5	1	0	6	0.045
No	0	1	4	5	

Table 5. Correlation of preoperative and intraoperative factors with outcome

Factors	Clinical outcome				p-value
	Improvement	Stable	Worse	Total	
Gender					
Male	6 (54.5)	2 (18.2)	3 (27.3)	11(47.8)	0.80
Female	8 (66.6)	2 (16.7)	2 (16.7)	12 (52.2)	
Age (years)					
<40	6 (60)	2 (20)	2 (20)	10 (43.4)	0.95
>40	8 (61.5)	2 (5.4)	3 (23.1)	13 (46.6)	
Vertical extension levels					
<3	10 (58.9%)	3 (17.6)	4 (23.5)	17 (74%)	0.76
>3	4 (66.6)	1(16.7)	1 (16.7)	6 (26%)	
McCormick					
I and II	10(62.6)	3(18.7)	3 (18.7)	16(69.5)	0.86
III and IV	4 (57.2)	1 (14.3)	2 (28.5)	7 (30.5)	
Extent of resection					
Total	9 (60)	2 (13.3)	4 (26.7)	15(65.2)	0.64
Partial	5 (62.5)	2 (25)	1 (12.5)	8 (34.8)	
Symptoms					
Pain	9 (69.2)	2 (15.4)	2 (15.4)	13	0.04
Motor	1 (12.5)	3 (37.5)	4 (50)	8	
Sensory	9 (64.2)	2 (14.3)	3 (21.5)	14	

neuromonitoring parameter had worse neurological outcomes (p=0.02). During surgery, individuals who demonstrated monitoring alterations and reverted to baseline potential had better neurological outcomes than those who did not (p=0.045).

Parameters examined and postoperative functional results are shown in Table 5. The results were unaffected by gender, age, vertical extension of the lesions, preoperative McCormick grade rate, and degree of resection. Initial motor symptom presentation and intraoperative IONM alteration were factors that affected the outcome. Patients with motor symptoms at diagnosis faired worse compared to those with sensory symptoms (p<0.05).

DISCUSSION

The incidence of spinal cord tumors in decreasing order are ependymomas, and astrocytomas followed by other tumors like hemangioblastomas, and lipomas.[3-6] As the majority of IMSCL are benign, gross-total resection would offer long-term survival.[7,13] This would require the use of an operative microscope, microsurgical techniques, and an IONM system that would guide the surgeon to avoid the unaffected part of the spinal cord.[14]

During a procedure, the spinal cord may sustain a direct injury, hypoxia, or stretching of the cord or nerve.[15] The IONM is a technology designed to provide patients with minimal morbidity and optimal outcomes both during and after surgery. Neuromonitoring helps a surgeon by giving real-time data on spinal cord function.[16] Since the introduction of IONM by Tamaki and Yamane in 1975,[17] monitoring techniques and modalities have continuously improved.[18-19] Recent years have seen increased acceptance of the use of IONM to reduce this risk by evaluation of SSEP, tcMEP, and EMG of pertinent nerve root myotomes.[9-10] However, the system is costly and not widely available, especially in low and middle-income countries and the role of its use is often debated.[7,11]

Our series describes the demographics, clinical and radiological characteristics, classification, and utilization of IONM in the management strategy of IMSCL in a major university hospital in Nepal. This is the first series of IONM in patients with IMSCL from a single center in Nepal, and although it is a small series from a worldwide standpoint, it provides insight into how these patients are managed in the Nepalese context.

The predominant histological diagnoses in our patient series were similar to the previous literature.[3-6] Most of the symptoms were sensory, pain, and motor in nature. Surgical resection is the preferred treatment for good-grade patients. Patients with worse outcomes include those with preoperative motor symptoms, higher grades, and decreased IONM signals with no recovery. Tumor resection was greatly aided by IONM in our series.

Fehlings et al.[20] in a systemic review of 103 papers provided low levels of evidence for IONM's ability to prevent the development of new or worsening perioperative neurological deficits and very low levels of evidence for its ability to reduce the rate of perioperative neurological deteriorations.

However, Nuwer et al.[21] in their systematic review of 40 studies on IONM following spinal surgery provided evidence that ongoing changes in IONM were associated with the development of new neurological impairments in the postoperative period, which is similar to our work. They gave a level A recommendation of risk of adverse outcomes in patients who displayed significant IONM changes during surgery.

Sala et al., in 2006, were able to determine the true impact of IONM (SSEP, mMEP, and D wave) in IMSCL surgery.[22] According to the authors, the evidence supporting the use of IONM in IMSCL surgery is still considered Class II and III evidence because prospective randomized trials are immoral and illegal from an ethical and legal standpoint. In a review of the use of IONM in spinal tumors by Scibilia, et al. also, the authors concluded that IONM is a valuable technique to help patients have satisfactory postoperative outcomes.[5]

Contrarily, Sandalcioglu et al.[23] found that 96.2% of patients with 131 spinal tumors treated with SSEPs had improved or stable neurological status, and 3% had worsened neurological status. They concluded that positive clinical outcomes were possible without the use of advanced monitoring. MEP and multi-modal monitoring could not reliably predict long-term functional impairments, according to other studies evaluating the impact of IONM in IMSCL.[24] The most frequent significant alterations are seen in intramedullary lesions. According to Wiedmayer, et al., the surgeon was unable to respond to a monitoring event in more than 50% of the cases.[25]

Based on our observations, the McCormick grade scales either improved or were unchanged in the immediate postoperative period compared to the preoperative condition when the intraoperative amplitudes of tcMEPs and SEPs are raised. However, intraoperative recovery of tcMEPs does indicate a postoperative improvement.[26] IONM has now been incorporated routinely into IMSCL surgery practice in many centers including ours.

Our study is not without limitations. The small sample size, multiple outcome variables, and single-center nature of the study make our result less generalizable.

CONCLUSION

Our study suggests that use of IONM decreases postoperative neurological deficits. This strengthens the previous concept that IONM is an indispensable tool during surgery for IMSCL. Though costly, with increasing consumer awareness and increasing detection of complex tumors, IONM will be regarded as a minimum standard in all neurological centers in near future. However, other factors should be taken into consideration while contemplating spinal tumor surgery. Further multi-centric larger studies are recommended to gain more insight into IONM.

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CONFLICT OF INTEREST

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