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ORIGINAL ARTICLE

Outcome of Optimal Surgical Resection of Spinal Cord Tumors with Using of Intra-Operative Neuro-Monitoring

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Abstract

Background: ***Despite making up a small percentage of neoplasms of the central nervous system (CNS), spinal cord tumors have an extensive impact on the quality of life of patients. From primary tumors to secondary lesions, they pose significant difficulties. There is a considerable risk of adverse consequences while undergoing surgical surgery. However, the advent of intraoperative neuromonitoring (IONM), which promises better postoperative trajectories, is a bright light of hope.***

Aim and objectives: ***To evaluate the efficacy of intraoperative neuromonitoring during gross total surgical resection of spinal cord tumors in predicting postoperative outcomes at our institution.***

Patients and methods: ***The study included 60 patients who were presented to Al-Azhar University Hospitals with spinal cord tumors at different vertical and horizontal levels. The study included patients who underwent microscopic surgery for complete excision of spinal cord tumors using (IONM), comparing the intraoperative IONM changes with the postoperative neurological outcomes.***

Results: ***The occurrence of intraoperative changes was significantly correlated with postoperative deficits. A statistically significant (p-value=0.016) increase in the percentage of immediate, 1-, and 3-month postoperative deficits in patients was correlated with intraoperative trans-minor changes (6 patients, 18.8%) when compared with intraoperative stable patients (0 patients, 0%).***

Conclusion: ***Intraoperative neuromonitoring continues to play a crucial role in predicting the postoperative surgical outcomes of spinal cord tumors at various levels when maximum resection is intended. We discussed the significance of IOMN in elevating patient care standards and diminishing the occurrence of surgical complications, referring to the technical and legal implications.***

Keywords: Surgical resection; Spinal cord tumors; Intra-operative neuro-monitoring

1. Introduction

Although spinal cord tumors comprise a relatively small proportion of central nervous system neoplasms,[1,2,3,4] they exert a profound impact on patient quality of life. Spanning from primary neoplasms to secondary lesions, they present formidable challenges.[3,4,5,6,7,8] Diagnosis primarily relies on magnetic resonance imaging (MRI), occasionally supplemented by a computed tomography scan (CT) for precise spinal assessment. Diagnosis primarily relies on (MRI), occasionally supplemented by a (CT) for precise spinal assessment.[9,10] Treatment modalities include surgery,[11] chemotherapy [6,7,12,13,1415] immunotherapy, radiation therapy, and radiosurgery20, with surgical intervention being the gold standard.[10,15]

Surgical excision represents significant potential for serious outcomes, particularly when a complete excision is intended. However, the emergence of (IONM) brings a beacon of hope, offering the promise of improved postoperative trajectories. Numerous studies have examined the effectiveness of such vigilant oversight in spinal cord tumor surgeries.[15]

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The purpose of this study was to determine whether intraoperative neuromonitoring, used in gross complete surgical excision of spinal cord tumors, is a reliable predictor of postoperative outcomes at our facility. The purpose of this study question is to evaluate intraoperative neuromonitoring's effectiveness in predicting postoperative outcomes. It does not, however, include research on the effectiveness of monitoring to prevent complications or improve surgical resection. Referring to the technical and legal ramifications, we discussed the importance of IOMN in improving patient care standards and reducing the incidence of surgical complications.

2. Patients and methods

Patients who underwent intraoperative neuromonitoring during microscopic surgery to remove spinal cord malignancies are included in the study. Data for this study were gathered through the analysis of records between March 1, 2023, and October 1, 2023.

Criteria for inclusion and exclusion

All patients, regardless of age, who had been diagnosed with spinal cord neoplasms were included. Individuals with vascular malformations, cysts, eosinophilic granuloma, and sarcoid tumors were excluded.

Preoperative evaluation

Prior to surgery, patients underwent history taking, neurological examination, and radiological investigation, including MRI and CT scans. Preoperative laboratory evaluation and viral markers screening. Consent was obtained from patients or representatives. Preoperative medications included steroids and parenteral antibiotics. Anesthesia is considered intraoperative neurophysiologic monitoring. Patients were positioned prone on the operating table with appropriate padding. IONM modalities used included MEP, SSEP, and EMG.

Operative Technique:

Posterior spine exposure involved a midline incision, subcutaneous, and paraspinal muscle dissection, exposing one level above and below the lesion. Laminectomy, either total or partial, was performed based on lesion size and surgeon preference, with hemostasis established. Lesion exposure and resection involved microscopic cranial and caudal durotomy, with dural edges sutured to prevent blood entry. Tumor volume reduction was done using an ultrasonic aspirator, with MEPs and SEPs monitoring. The closure included tension-free, watertight dural closure, possible autoplasty using autologous fascia, and subfascial drain placement, followed by skin closure.

Postoperative follow-up:

Patients received immediate postoperative neurological assessment and were followed up at one and three months. Follow-up included wound healing, skin stitch removal, observation for wound inflammation and CSF leaks, management of complications, and neurological evaluation. MRI with contrast assessed lesion removal, presence of pseudomeningocele, and CSF leaks. Histopathological examination or biopsy provided further follow-up in the oncology clinic.

Statistical analysis:

Statistical analysis used SPSS v26. Normality was assessed with the Shapiro-Wilks test and histograms. Parametric data were presented as mean ± SD, non-parametric as median (IQR), and qualitative as frequency (%). Chi-square or Fisher's exact test analyzed qualitative data. $P \leq 0.05$ indicated significance.

3. Results

The current study was conducted on 60 patients (27 male and 33 female) aged 2–70 years (mean 37.6).

Table 1. description of demographic data in all studied patients.

		STUDIED PATIENTS (N=60)	
SEX	Male	27	45%
	Female	33	55%
AGE (YEARS)	Mean±SD	37.6±18.1	
	Min-Max	2-70	

The mean age of all studied patients was 37.6±18.1 years with minimum age of 2 years and maximum age of 70 years. There were 27 males (45%) and 33 females (55%) in the studied patients, Table 1.

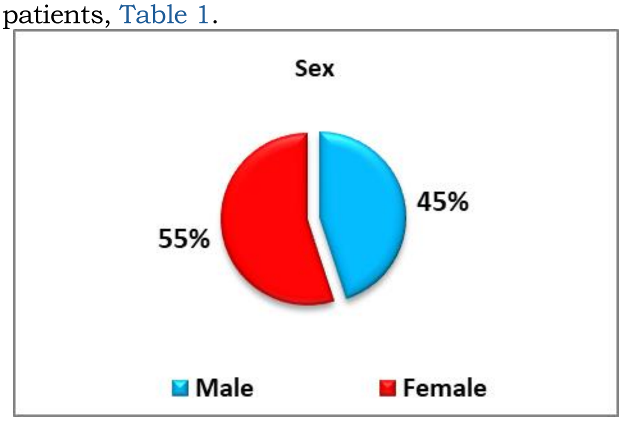

Figure 1. description of sex in all studied patients.

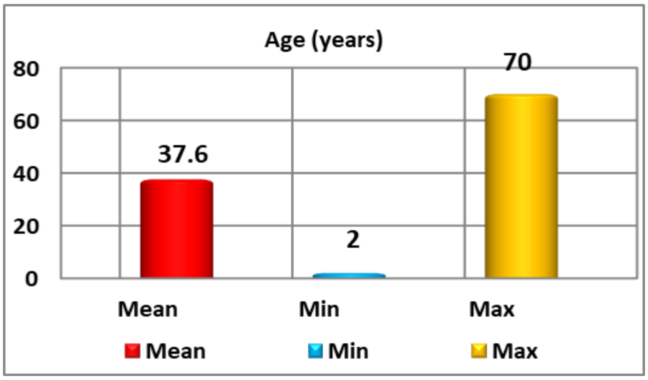

Figure 2. description of age in all studied patients.

Table 2. description of comorbidities in all studied patients.

		STUDIED PATIENTS (N=60)	
COMORBIDITIES	DM	14	23.3%
	HTN	16	26.7%
	IHD	4	6.7%
	COPD or asthma	8	13.3%
	Smoking	18	30%

There was DM in 14 patients (23.3%), HTN in 16 patients (26.7%), IHD in 4 patients (6.7%), COPD or asthma in 8 patients (13.3%) and smoking in 18 patients (30%), Table 2.

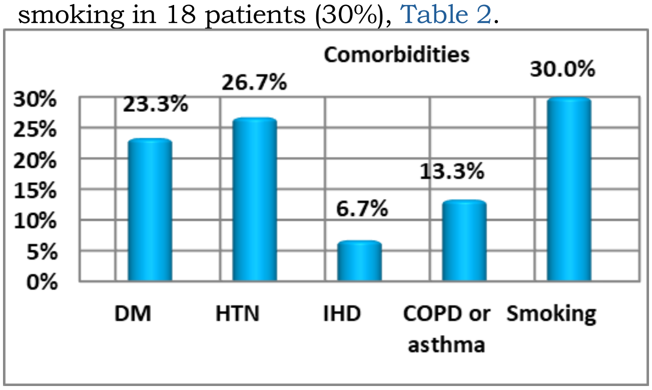

Figure 3. description of comorbidities in all studied patients.

Table 3. description of pre-operative data in all studied patients.

		STUDIED PATIENTS (N=60)	
MRC GRADING	Grade 0	1	1.7%
	Grade I	2	3.3%
	Grade II	2	3.3%
	Grade III	13	21.7%
	Grade IV	17	28.3%
	Grade V	25	41.7%
MODIFIED MC CORMICK SCALE	Grade I	19	31.7%
	Grade II	18	30%
	Grade III	8	13.3%
	Grade IV	14	23.3%
	Grade V	1	1.7%

In MRC grading: grade 0 is the worest (plegia), while in modified Mc Cormick scale: grade V is the worest (plegia). As regard MRC grading, it was grade 0 in 1 patient (1.7%), grade I in 2 patients (3.3%), grade II in 2 patients (3.3%), grade III in 13 patients (21.7%), grade IV in 17 patients (28.3%) and grade V in 25 patients (41.7%). As regard Modified Mc Cormick scale, it was grade I in 19 patients (31.7%), grade II in 18 patients (30%), grade III in 8 patients (13.3%), grade IV in 14 patients (23.3%) and grade V in 1 patient (1.7%), Table 3.

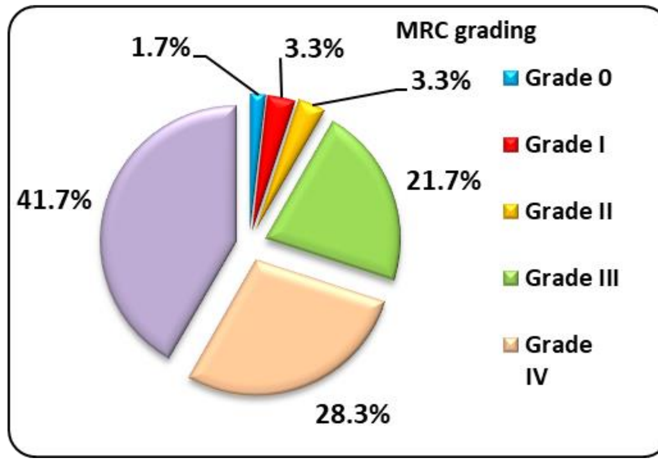

Figure 4. description of MRC grading in all studied patients.

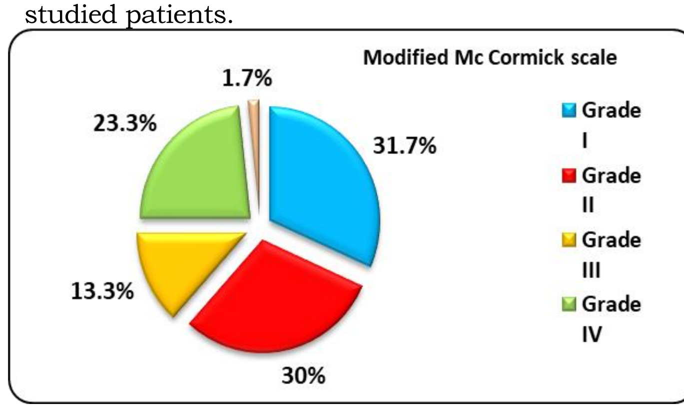

Figure 5. description of modified Mc Cormick scale in all studied patients.

Table 4. description of Neurological outcomes in all studied patients.

		STUDIED PATIENTS (N=60)	
IMMEDIATE WORSENED OR NEW DEFICIT	No	54	90%
	Yes	6	10%
WORSENED OR NEW DEFICIT AT 1 OR 3 MONTHS	No	56	90%
	Yes	6	10%

There were 6 patients (10%) with immediate worsened or new deficit and also at 1 or 3 months. All the 6 patients had Sphinctric affection 3 of them had weakness, Table 4.

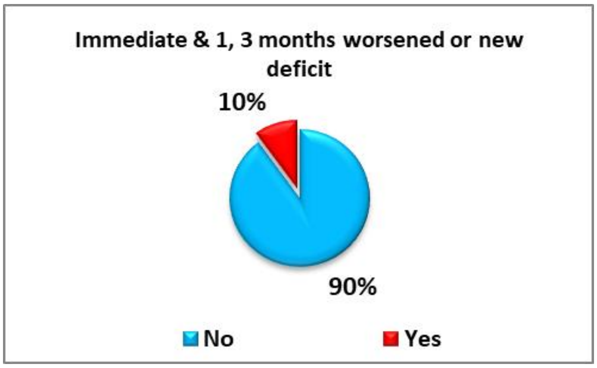

Figure 6. description of immediate, 1 or 3 months worsened or new deficit in all studied patients.

Table 5. correlation between IONM and neurological outcomes in all studied patients.

		IONM				STAT. TEST	P-VALUE
		Stable (N=28)		Trans-minor changes (N=32)			
IMMEDIATE, 1- OR 3-MONTHS DEFICIT	No	28	100%	26	81.3%	X2=5.8	0.016 S
	Yes	0	0%	6	18.8%		

X2:Chi-square test. S: p-value<0.05 is considered significant.

This table shows statistically significant (p-value=0.016) increased percentage of immediate, 1- or 3-months deficit in patients with trans-minor changes (6 patients, 18.8%) when compared with stable patients (0 patients, 0%), Table 5.

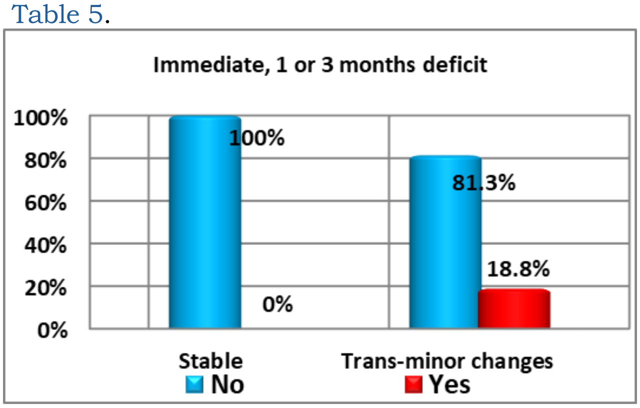

Figure 7. correlation between IONM and neurological outcomes in all studied patients.

Table 6. description of IONM in studied patients.

		N	%
IONM IN INTRAMEDULLARY PATIENTS (N=26)	Stable	3	11.5%
	Trans Minor Changes	23	88.5%
IONM IN INTRA-DURAL EXTRA-MEDULLARY PATIENTS (N=22)	Stable	15	68.2%
	Trans Minor Changes	7	31.8%
IONM IN EXTRA-DURAL (N=12)	Stable	10	83.3%
	Trans Minor Changes	2	16.7%

In Intra-medullary patients (n=26), it was stable in 3 patients (11.5%) while there were trans minor changes in 23 patients (88.5%). In Intra-Dural extra-medullary patients (n=22), it was stable in 15 patients (68.2%) while there were trans minor changes in 7 patients (31.8%). In Extra-Dural patients (n=12), it was stable in 10 patients (83.3%) while there were trans minor changes in 2 patients (16.7%), Table 6.

Table 7. description of immediate, 1- or 3-months deficit in studied patients.

		N	%
DEFICIT IN INTRAMEDULLARY PATIENTS (N=26)	No	23	88.5%
	Yes	3	11.5%
DEFICIT IN INTRA-DURAL EXTRA-MEDULLARY PATIENTS (N=22)	No	20	90.9%
	Yes	2	9.1%
DEFICIT IN EXTRA-DURAL (N=12)	No	11	91.7%
	Yes	1	8.3%

In Intra-medullary patients (n=26), there was deficit in 3 patients (11.5%). In Intra-Dural extra-medullary patients (n=22), there was deficit in 2 patients (9.1%). In Extra-Dural patients (n=12), there was deficit in 1 patient (8.3%), table 7.

4. Discussion

This study was conducted at Al Azhar University Hospitals and was carried out on 60 patients diagnosed with spinal cord tumors. The study included patients who underwent microscopic surgery for excision of spinal cord tumors with the use of intra-operative neuro-monitoring. Data was collected in the period from March 1, 2023, to October 1, 2023, with reviewing of old records.

The main aim of this study was to evaluate the outcome of optimal Surgical resection of spinal cord tumors with the use of intra-operative neuro-monitoring.

Around one-fifth of the primary neurogenic tumors originate within the spinal canal.[1,2,3,4] Those arising from spinal tissues are termed primary intraspinal tumors,[1] while those originating from tissues outside the spinal canal or spreading to spinal tissues via metastasis are referred to as secondary intraspinal tumors.[5,6,7] Metastatic tumors represent the most prevalent type of spinal tumor and are malignant, indicating the potential for further spread and typically exhibiting rapid growth.[5,6,7]

Although spinal cord tumors are uncommon, they are crucial in diagnosing patients with autonomic dysfunction, radicular or back pain, and sensorimotor deficits. The complexity of spinal cord physiology and anatomy poses significant challenges in diagnosing and treating spinal cord disorders.[4,8]

Surgical decompression, with or without instrumentation, is the preferred treatment for patients exhibiting signs or symptoms of tumor growth. Total resection is considered the optimal approach for most intraspinal tumors, representing the "gold standard." However, when tumors are located near critical structures, total resection may pose safety concerns.

In spinal surgery, excising a lesion from within the spinal cord always entails the potential for postoperative neurological deficits.

(IONM) plays a crucial role during the surgical resection of spinal cord tumors. These monitoring techniques help surgeons navigate delicate procedures while minimizing the risk of damage to the spinal cord and surrounding nerves.

Commonly used IONM during such surgeries include somatosensory Evoked Potentials (SSEPs), motor Evoked Potentials (MEPs), electromyography (EMG), Transcranial Electrical Stimulation (TES), Dorsal Column Mapping, and Spinal Cord Blood Flow Monitoring.

By combining these modalities, surgeons can obtain real-time feedback on the functional integrity of the spinal cord and make informed decisions during tumor resection to optimize patient outcomes and minimize the risk of neurological complications.

In our cases, the motor and sensory tracts were monitored using the MEP and SSEP modalities. In situations involving extramedullary lesions, such as neurofibromas, schwannomas, filum terminal lesions, or lumbosacral lesions, where only a limited number of nerve roots are impacted, we have integrated (EMG) into our monitoring approach.

In the current study we found that there was DM in 14 patients (23.3%), HTN in 16 patients (26.7%), IHD in 4 patients (6.7%), COPD or asthma in 8 patients (13.3%) and smoking in 18 patients (30%).

Effective management of diabetes and hypertension is critical for patients undergoing spinal cord tumor surgery. Preoperative control and close monitoring postoperatively are essential to minimize complications and optimize outcomes. Collaborative care involving a multidisciplinary team is key for addressing the complex needs of these patients throughout the perioperative period.

In the current study, we found that as regards MRC grading, it was grade 0 in 1 patient (1.7%), grade I in 2 patients (3.3%), grade II in 2 patients (3.3%), grade III in 13 patients (21.7%), grade IV in 17 patients (28.3%) and grade V in 25 patients (41.7%). As regards the Modified Mc Cormick scale, it was grade I in 19 patients (31.7%), grade II in 18 patients (30%), grade III in 8 patients (13.3%), grade IV in 14 patients (23.3%) and grade V in 1 patient (1.7%). Grade 0 is the worst in MRC grading, while grade V is the worst.

Patients with higher preoperative MRC grades tend to experience better postoperative outcomes, including enhanced neurological function and shorter hospital stays, while those with lower grades face slower recovery and increased risks. Preoperative assessment of muscle strength using the MRC grading system is crucial for guiding treatment strategies in spinal cord tumor resection.

In the current study we found that regarding lesion location, it was cervical in 9 patient (15%), Cervico-dorsal in 1 patient (1.7%), dorsal in 20 patients (33.3%), Dorso-lumber in 10 patients (16.7%), lumber in 16 patients (26.7%), sacral in 3 patients (5%) and whole cord in 1 patient (1.7%).

The location of spinal cord tumors significantly impacts surgical decisions and outcomes. Understanding anatomical and functional aspects associated with different locations is crucial for optimal patient care. It affects accessibility, risk of neurological injury, surgical approach, and long-term prognosis.

In the current study we found that regarding histopathology, there was Astrocytoma in 6 patient (10%), Cavernoma in 2 patient (3.3%), Chordoma in 1 patient (1.7%), Ependymoma in 14 patients (23.3%), Hemangioma in 1 patient (1.7%), Lipoma in 4 patients (6.7%), Meningioma in 11 patient (18.3%), Metastatic adenocarcinoma in 8 patient (13.3%), Neurofibroma in 10 patient (16.7%), Osteoid Osteoma in 1 patient (1.7%), Plasmacytoma in 1 patient (1.7%) and Schwannoma in 1 patient (1.7%).

Ependymoma was the most common tumor in our series, followed by meningioma, then neurofibroma.

Histopathological type significantly influences postoperative outcomes in spinal cord tumors. Benign tumors like ependymomas and meningiomas typically result in better outcomes post-surgery, with complete resection often leading to long-term symptom relief and low recurrence rates. In contrast, malignant tumors such as glioblastomas or metastatic tumors may require aggressive treatments and still yield poorer prognosis and functional outcomes due to their infiltrative nature and higher recurrence risk.

In our study we found that as regards surgical access, it was total laminectomy in 52 patients (86.7%), total Laminectomy é Fixation in 7 patients (11.7%) and partial laminectomy in 1 patient (1.7%).

Surgical approach selection relies on tumor characteristics like location, size, and relationship to surrounding neural structures. Neurosurgeons assess each case to choose the best approach for maximizing resection and minimizing complications while preserving neurological function.

As regard IONM, it was stable in 28 patient (46.7%) and trans-minor changes in 32 patients (53.3%). Those patients with trans-minor changes were recovered and continued surgery.

Continuous monitoring and interpretation of IONM data in surgery enable real-time detection of neural function changes, facilitating prompt intervention to prevent or lessen neurological injury. Collaboration among surgeons, neurophysiologists, and anesthesia providers enhances safety and effectiveness in procedures involving neural structures.

As regards operative time, the mean operative time of all studied patients was 3.45±0.77 hours, with a minimum operative time of 2.5 hours and a maximum operative time of 6 hours.

Operative time for spinal cord tumor resection varies based on tumor size, location, procedure complexity, approach, and patient health. Surgeons aim for optimal tumor removal while prioritizing patient safety, with operative times ranging from hours to a day or more.

In our study we found that as regard hospital stay, the mean hospital stay of all studied patients was 5.35±2.26 days with minimum hospital stay of 3 days and maximum hospital stay of 15 days. Hospital stay duration post-surgical spinal cord tumor resection varies based on patient health, surgery extent, complications, and recovery progress.

As regards general postoperative complications, there was UTI in 2 patients (3.3%) while there were no general complications in the remaining 58 patients (96.7%). Regarding regional postoperative complications, there was SSI in 8 patients (13.3%) and CSF leak in 5 patients (8.3%), while there were no regional complications in 52 patients (86.7%).

Patients undergoing spinal cord tumor resection should know possible complications and promptly discuss concerns with healthcare providers. Monitoring, proactive management, and following postoperative instructions aid in reducing risks and ensuring successful recovery.

In our study we found that regarding neurological outcomes, there were 6 patients (10%) with immediate worsened or new deficit and also at 1 or 3 months. All the 6 patients had Sphincteric affection 3 of them had weakness.

In Intra-medullary patients (n=26), there was a deficit in 3 patients (11.5%). In Intra-Dural extra-medullary patients (n=22), there was a deficit in 2 patients (9.1%). In Extra-Dural patients (n=12), there was a deficit in 1 patient (8.3%).

In our study we found that statistically significant (p-value=0.016) increased percentage of immediate, 1- or 3-months deficit in patients with trans-minor changes (6 patients, 18.8%) when compared with stable patients (0 patients, 0%).

The research inquiry is centered on assessing the efficacy of intraoperative neuromonitoring during surgical resection of spinal cord tumors, specifically in predicting postoperative outcomes. However, it does not encompass the investigation into the utility of monitoring in averting complications or enhancing overall surgical outcomes.

4. Conclusion

Intraoperative neuromonitoring continues to play a crucial role in predicting postoperative surgical outcomes in spinal cord tumors at various levels when maximum resection is intended. This research inquiry is centered on assessing the efficacy of intraoperative neuromonitoring, specifically in predicting postoperative outcomes. However, it does not encompass the investigation into the utility of monitoring in averting complications or enhancing surgical resection.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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