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Aspects of Neuromonitoring Used By Neurosurgeons among Tertiary and University Hospitals in Lebanon

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ABSTRACT

Aims: *Intraoperative neurophysiological monitoring (IONM) is being more implemented in medical practices and routinely used during surgical procedures.*

This study aims to assess neurosurgeons' knowledge, attitude, and practices regarding the techniques of neuromonitoring used in spine surgeries, and the limitations that prevent them from implementing these techniques in care optimization. It also aims to determine which interventions are most effective at avoiding postoperative complications following IONM alerts.

Results: *Among the participating neurosurgeons, 16.7% confirmed adopting IONM regularly, while the majority (58.3%) rarely used spinal cord monitoring. One neurosurgeon, however, stated that he never used any monitoring. More than 80% of neurosurgeons thought IONM modalities were useful for spinal procedures.*

Discussion: *IONM of the spinal cord is changing dramatically as a result of the recent technological advancements and the development of a wide range neurophysiological techniques to improve patient outcomes. This contribution in enhancing the safety of spinal procedures and limiting potential iatrogenic neurologic injuries has made IONM more popular among neurosurgeons. Additionally, more than 80% of neurosurgeons considered IONM modalities to be useful for spinal procedures.*

Conclusion: *IONM is a highly useful neuromonitoring technique to identify the signs of potential postoperative neurologic deficits and avoid possible subsequent sequelae. Physicians should have enough knowledge regarding the proposed surgery, and the preferred types of IONM to be employed, and understand the influence of drugs and anesthetic techniques on evoked potentials in order to choose the most appropriate neuromonitoring approach.*

Keywords
Neuromonitoring, Neurosurgeon, Intraoperative neuro-physiological monitoring.

Introduction
Electronic medical records, mobile health apps, and wearable technology are just a few examples of how digital health technology is beginning to be heavily adopted in patient care. Neurosurgery is one of the fastest-growing fields where machine learning is being applied to give surgeons a better understanding of the pathophysiology and prognosis of neurological conditions [1].

While successful operations can benefit patients, surgical errors can have deleterious outcomes. For instance, although rare, neural injury is of significant concern in spine procedures because it has the inherent potential to provoke serious postoperative motor and sensory impairments. As intraoperative neurophysiological monitoring (IONM) provides a real-time evaluation of the neurological structures at danger, this technique is frequently used to increase the safety of spine surgeries [1]. It consists of a group of procedures used to monitor neural pathways during high-risk neurosurgical, orthopedic, peripheral nerve, and vascular surgeries, in order to prevent damage and preserve the functionality of the nervous system [2].

In addition, this monitoring technique requires both the identification of crucial brain structures and the ongoing monitoring of neural tissue. In fact, IONM has the ability to identify intraoperative neural injuries that can be treated before they cause permanent harm or postoperative deficits. Since no evidence-based recommendations exist for the safe and effective application of IONM, the surgeon's preferences, as well as the medicolegal considerations, largely determine how this monitoring tool is employed. Moreover , there are divergent views on the best ways to combine various tools in order to boost the safety of spine surgeries [3].

Despite all the improvements in this particular field, false-positive warnings are still reported, which can occasionally prompt the surgical team to take irrational precautions. This problem constitutes a contentious issue with IONM [4]. Therefore, the management of IONM warnings within the spine surgery community is variable, which may account for the lack of a discernible change in the overall rate of neurological events [5]. Furthermore, a recent proposal to execute a strategy integrating two or more modalities has evolved as a result of the lack of standardization and the limits of some modalities when employed alone. For this reason, the preoperative sign-in provides an essential opportunity for a multidisciplinary communication and coordination between the three components of the surgical team: the neurosurgeon, the anesthesiologist, and the neuromonitoring staff [6].

Various IONM techniques are used during surgery to assess how the brain, brainstem, spinal cord, and nerves are functioning. In fact, the adoption of additional neuromonitoring techniques throughout the surgical procedure has increased, as the benefits of monitoring are becoming more apparent [3]. Among these techniques, electromyography (EMG), Electroencephalography (EEG), Somatosensory Evoked Potential (SSEP), Motor Evoked Potential (MEP), Visual Evoked Potential (VEP), and Brainstem Auditory Evoked Potential are among the most frequently used (BAEP) [7].

As the costs of spine surgeries continue to rise, particularly in a country experiencing a severe economic collapse like Lebanon, this study is crucial to determine neurosurgeons' knowledge, attitude and practices regarding the utilization of different IONM techniques, and to inspect their extent of application during spine surgeries performed in Lebanese tertiary hospitals. In addition, this study aims to determine the effectiveness of IONM adoption, by assessing postoperative outcomes, such as neurological complications, pain control, length of hospitalization, and functional postoperative state, following IONM alerts.

Materials and Methods

Study design

This paper consists of a cross-sectional study that aims to assess the knowledge, attitude and practices among neurosurgeons towards IONM. It was conducted in Lebanese tertiary hospitals where major spine surgeries take place.

Participants

The participants in this study consisted of neurosurgeons who were involved in spine surgeries performed in Lebanese tertiary hospitals between 2015 and 2020. Among these neurosurgeons, those who were registered in the Lebanese order of physicians (LOP) and who consented to participate, were surveyed about their knowledge, attitude and practices towards IONM.

Sample Size

Based on an estimated population of 90 neurosurgeons according to LOP, we anticipated a response of 50%, a confidence level of 95%, and a 5% margin of error: the required sample size would be at least 74. This sample size was calculated using the online RAOSOFT sample size calculator, designed specifically for surveys.

Data collection, Instruments used, and Measurements

A questionnaire was distributed to all neurosurgeons willing to participate in this study, in order to assess their knowledge, attitude, and practices related to various types of IONM techniques during spine surgeries.

Statistical analysis

The collected data was coded, entered, and analyzed on the Statistical Package for Social Sciences (SPSS) software version 24 (IBM, SPSS statistics). Descriptive analysis was performed using numbers and percentages (prevalence) for qualitative variables and averages with standard deviations for continuous variables. A *p*-value less than or equal to 0.05 is considered statistically significant.

Ethical considerations

This study was conducted after receiving approval from the Institutional Review Board at the hospitals where this study took place. After viewing the objectives of this study, subjects willing to participate gave an informed consent. All participants were informed about the confidentiality, privacy, and anonymity of their data, and were totally free to leave the study at any time. Names and information of the participants are kept confidential and are not shared with any third party.

Results

Characteristics of the sample

Of a sample of 90 neurosurgeons registered in LOP, we attempted to contact 12 physicians working in university hospitals, who agreed to participate in this survey and completed the questionnaire. Of the total sample, 75% practiced in Beirut, 83.3% stated that they do not work outside Lebanon, and 66.7% reported practicing medicine for more than 10 years. More than half of the neurosurgeons (58.3%) in this study reported that they work with adult patients and 41.7%

deal with both pediatric and adult patients. Finally, regarding the use of IONM, most of the neurosurgeons (75%) reported that they used IONM during their training years. The description of the study population is shown in Table 1.

Table 1: Description of the study population.

Variables	Frequency (%)
Practice region	
Beirut	9 (75.0%)
Mont Lebanon	1 (8.3%)
Nabatieh	1 (8.3%)
Bekaa- Baalbeck	1 (8.3%)
Working outside Lebanon	
No	10 (83.3%)
Yes	2 (16.7%)
Years of practice	
0-5 years	2 (16.7%)
5-10 years	2 (16.7%)
Greater than 10 years	8 (66.7%)
Type of patients	
Pediatric patients	0 (0.0%)
Adults patients	7 (58.3%)
Both	5 (41.7)
Utilization of IONM	
During training	9 (75.0%)
Later	3 (25.0%)

The majority of the neurosurgeons included in this study expressed interest in spinal surgeries (92%), while about 75% were interested in brain injuries and neuro-oncology. Additionally, 58% of neurosurgeons were interested in skull base surgeries. Only one neurosurgeon, however, stated that he was interested in pediatric neurosurgery and epilepsy, as seen in Figure 1.

Use of IONM modalities in spinal surgeries

Half of the neurosurgeons participating in this study reported performing more than 100 spine surgeries per year, 16.7% reported performing 50-100 spine surgeries per year, and a remaining 33.3% reported performing 10-50 spine surgeries per year (Table 3).

In terms of routine use of spinal cord monitoring, only two neurosurgeons (16.7%) confirmed adopting regular monitoring techniques. The majority of participants (7/12, 58.3%) used spinal cord monitoring rarely. One neurosurgeon, however, stated that he never used any spinal cord monitoring. These findings are better shown in Table 2.

Table 2: The number of spine surgeries performed per year, and the use of spinal cord monitoring among neurosurgeons in Lebanon.

Variables	Frequency (%)
Number of spine surgeries/year	
< 10	0 (0.0%)
10-50	4 (33.3%)
50-100	2 (16.7%)
>100	6 (50.0%)
Use of spinal cord monitoring	
Never	1 (8.3%)
Rarely (1-25%)	7 (58.3%)
Sometimes (25-50%)	1 (8.3%)
Often (50-75%)	1 (8.3%)
Routinely/almost always	2 (16.7%)

Neural surgery types and IONM modalities

As illustrated in Figure 2, 58% of neurosurgeons use IONM when performing posterior cervical surgeries with myelopathy, while only 33% use IONM when performing posterior cervical surgeries without myelopathy. Furthermore, we noticed that half of neurosurgeons adopt IONM techniques in anterior cervical surgeries with myelopathy, and 25% in anterior cervical surgeries without myelopathy.

Additionally, IONM was used in the following other types of neural surgeries: 42% and 33% for anterior and posterior thoracic surgeries, respectively, 25% for scoliosis with pedicles, and 8% for scoliosis without pedicles. However, only 8% reported using IONM when performing posterior lumbar surgeries, and not a single reported using it in cases of a anterior lumbar surgeries.

Discontinuation of Neuromonitoring

When asked about neuromonitoring discontinuation, the majority of neurosurgeons reported waiting for half an hour after correction, or until the wound is closed, while 17% reported discontinuing neuromonitoring when the anesthesiologist has finished his job (Figure 3).

Types of IONM modalities present in Lebanese institutions.

In the present study, 83% of neurosurgeons reported that MEP is available in their institution. Furthermore, 67%, 58%, and 50% of institutions offer SSEP, EEG, and EMG modalities, respectively. Other modalities were available in the following proportions: BAEP (42%), and VEP (17%). It is worth noting that one surgeon working in Beirut reported the total absence of any IONM modality in the institution where he works (Figure 4).

Effectiveness of IONM modalities

MEP was the most commonly used IONM modality in our study, with 91.7% of neurosurgeons confirming using it, followed by SSEP, which was utilized by 75% of neurosurgeons, while 33% declared using EEG. Furthermore, we noticed that 25% of neurosurgeons used EMG, and 16% used BAEP. However, none of the neurosurgeons in our study reported using VEP (Figure 5).

Furthermore, MEP was the most preferred IONM modality according to the participating neurosurgeons (83%), followed by SSEP (67%), and EMG (33%). Only 25% and 17% of respondents thought EEG and BAEP were the most preferred techniques, respectively as shown in Figure 6. Of particular note, two neurosurgeons has declared that, of all the IONM modalities, MEP has failed to provide a usable baseline.

In addition, more than 80% of neurosurgeons thought IONM modalities were useful for spinal procedures (Figure 7).

Alerts during surgeries

In terms of alerts during surgeries, participating neurosurgeons declared that 58.3% of alerts were directed towards the surgical team, 25% towards the anesthesia team, and 16.7% towards the technical team (Figure 8).

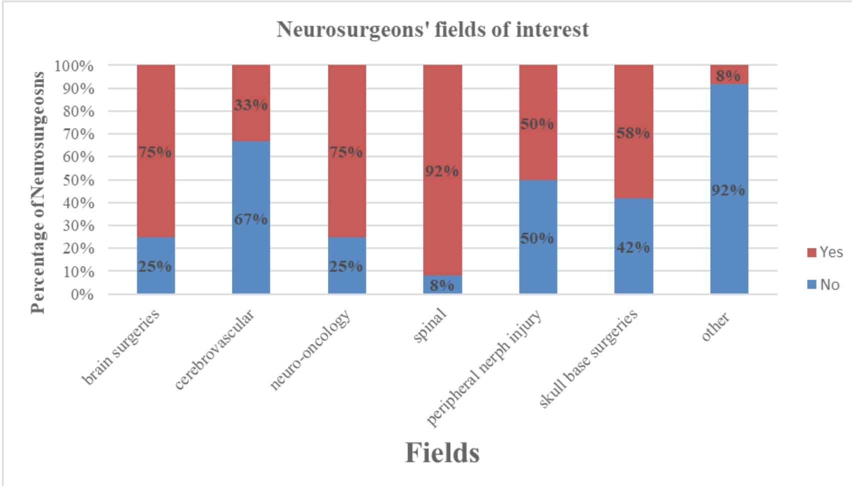

Figure 1: The distribution of neurosurgeons according to their interests.

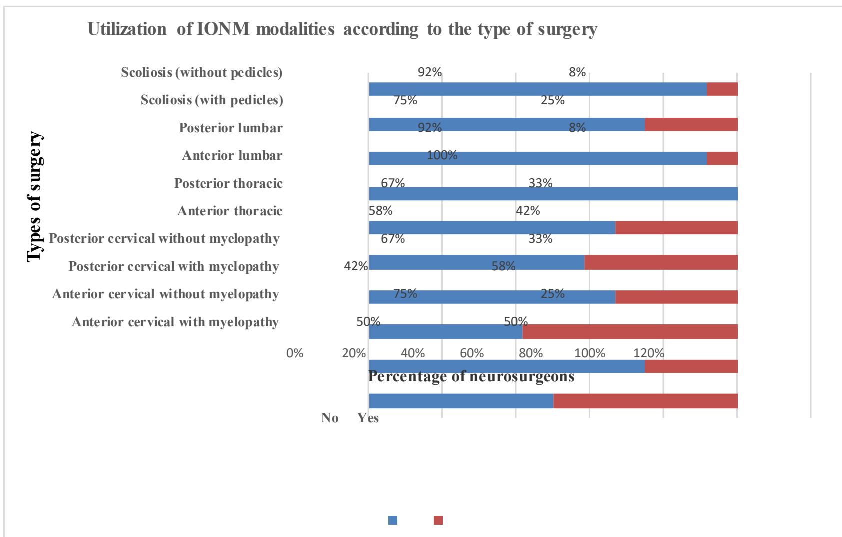

Figure 2: The utilization of IONM modalities according to the types of surgery.

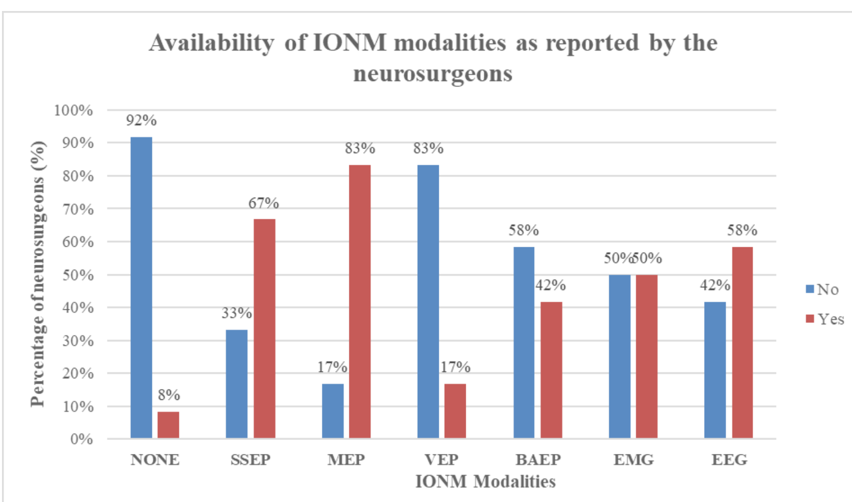

Figure 3: The times at which neurosurgeons discontinue neuromonitoring.

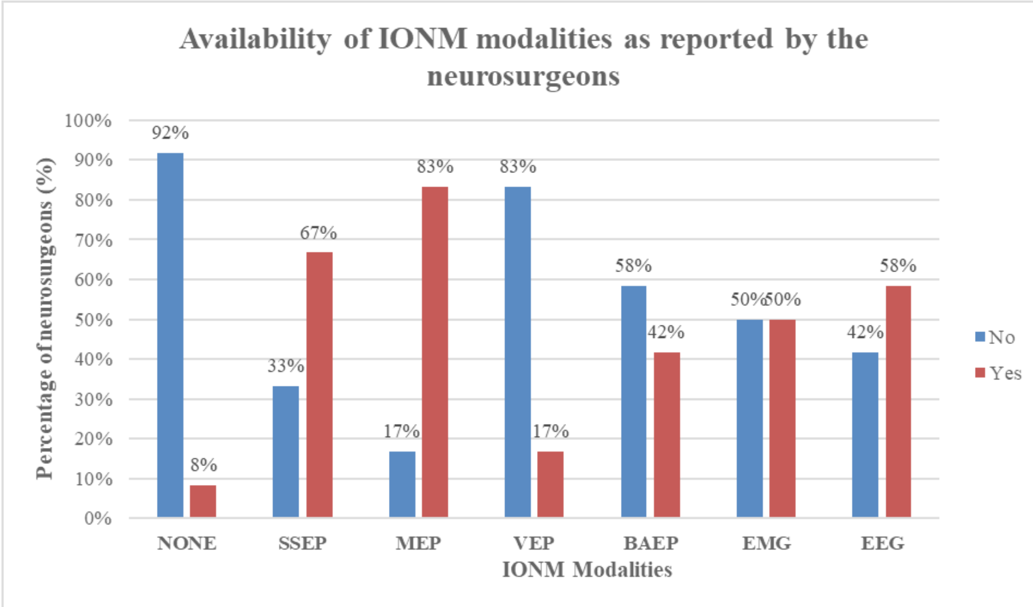

Figure 4: The availability of IONM modalities in various Lebanese hospitals, as reported by neurosurgeons.

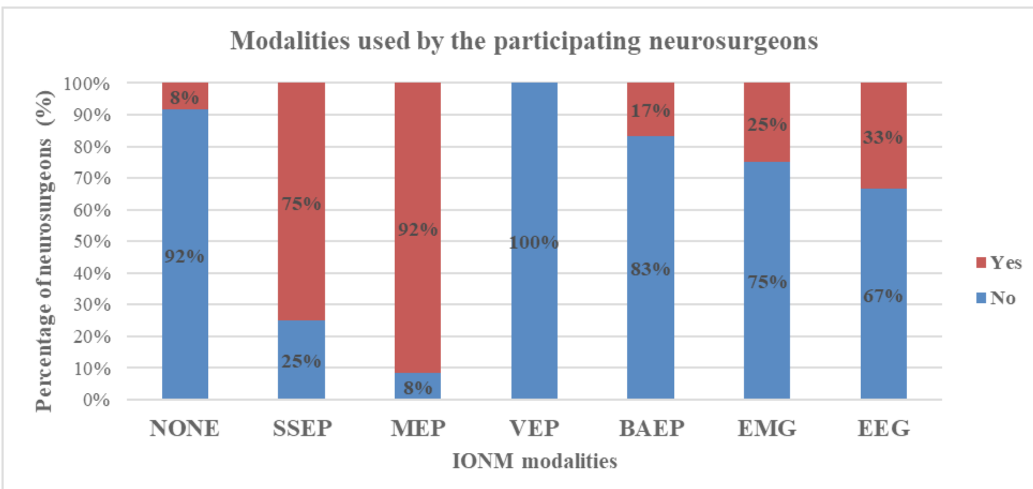

Figure 5: The most commonly used IONM modalities as reported by the participating neurosurgeons.

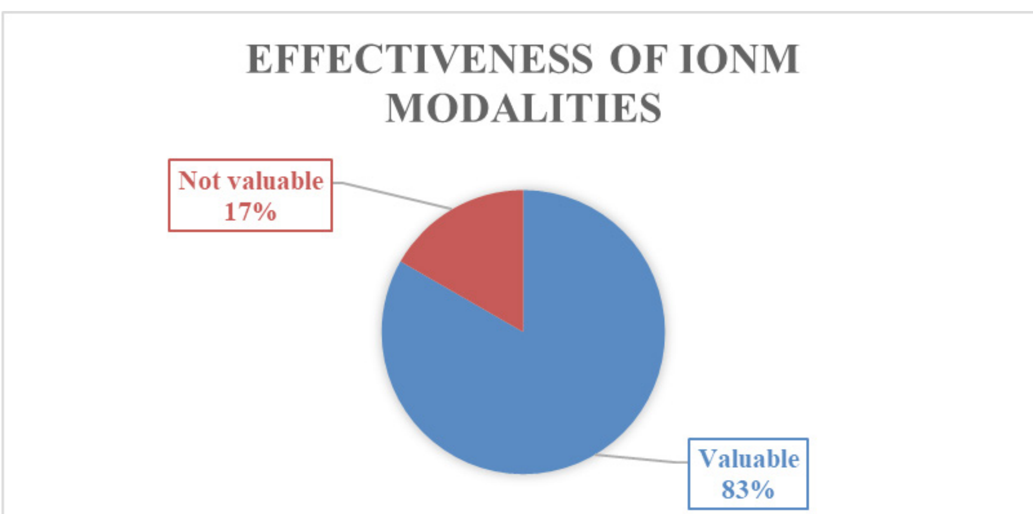

Figure 6: The most preferred IONM modalities according to our participants.

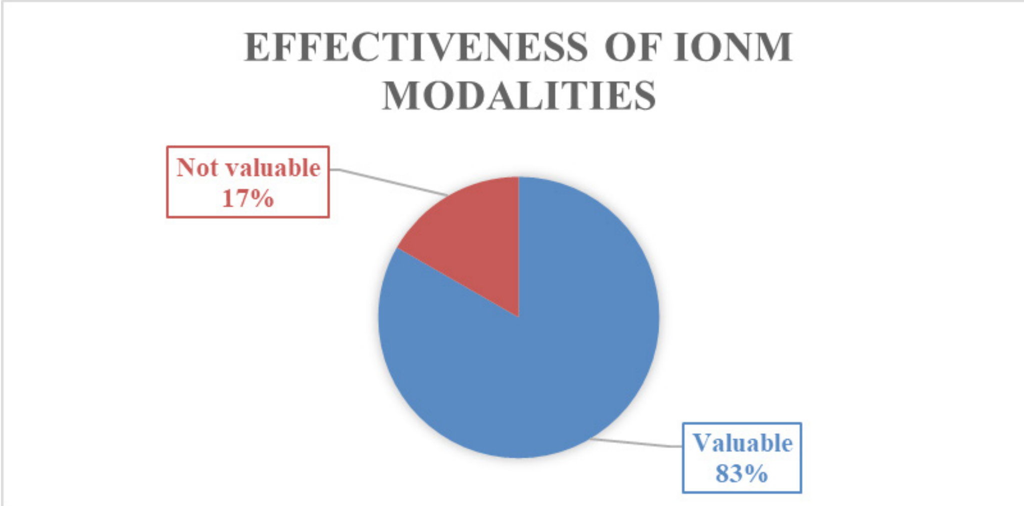

Figure 7: The effectiveness of IONM modalities according to the neurosurgeons.

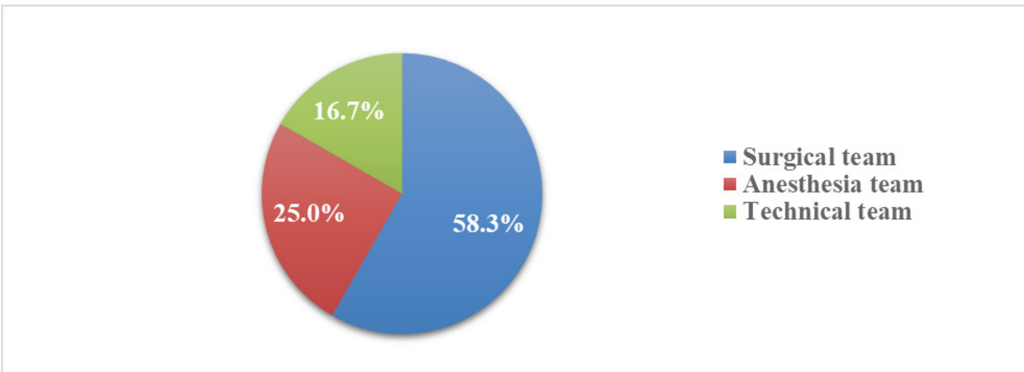

Figure 8: The various clinical teams involved in alerts during spinal surgeries.

Table 3: Alerts reported during spinal surgeries.

	Not applicable, I never use monitoring in these cases	Rarely (1-25%)	Sometimes (25-50%)	Often (50-75%)	Routinely /almost always
When an alert occurs during a spine surgery, how often do you think it provided you with intraoperative information that you found helpful?	1 (8.3%)	1 (8.3%)	4 (33.3%)	6 (50.0%)	0 (0.0%)
How often did an alert result in a negative outcome or was harmful to the patient?	1 (8.3%)	10 (83.3%)	1 (8.3%)	0 (0.0%)	0 (0.0%)

Table 4: Reasons for using IONM according to neurosurgeons.

	Very important N (%)	Fairly important N (%)	Important N (%)	Slightly important N (%)	Not at all important N (%)
Medicolegal protection and cover in case of development of neurologic postoperative complications	6 (50.0%)	3 (25.0%)	2 (16.7%)	1 (8.3%)	0 (0.0%)
Provision of self-assurance or peace of mind during surgery	3 (25.0%)	2 (16.7%)	3 (25.0%)	2 (16.7%)	2 (16.7%)
The overall cost/benefit ratio is worth it	1 (8.3%)	3 (25.0%)	5 (41.7%)	2 (16.7%)	1 (8.3)
Prevention of postoperative complications related to decompression, instrumentation, and grafting at a valuable rate	6 (50.0%)	2 (16.7%)	2 (16.7%)	2 (16.7%)	0 (0.0%)
Neurologic complications occurring outside of the surgical field itself at a valuable rate	2 (16.7%)	3 (25.0%)	3 (25.0%)	0 (0.0%)	4 (33.3%)

When an alert occurs during spine surgery, half of the neurosurgeons (50%) declared that this alert often provides them with intraoperative information that could be helpful. Furthermore, about 83.3% of neurosurgeons stated that an alert rarely results in a negative outcome or is harmful to the patients (Table 3).

Reasons for IONM application

To determine the primary reasons for IONM use, participating neurosurgeons were asked to rate the importance of each reason of application on a scale of 1 (very important) to 5 (not important at all) (Table 4). As a result, we found that the most important reasons for IONM implementation among neurosurgeons were: “medicolegal protection and cover in case of development of neurologic postoperative complications”, in addition to the “prevention of postoperative complications related to decompression, instrumentation, and grafting at a valuable rate”. It is worth noting that 50% of neurosurgeons considered these two statements to be the most important reasons for IONM implementation.

Furthermore, we noticed that 33.3% and 16.7% of neurosurgeons believed that using IONM modalities was unnecessary due to "neurologic complications occurring outside of the surgical field itself at a valuable rate", and “provision of self-assurance or peace of mind during surgery” respectively.

Discussion

When performing a neurosurgical procedure, both the physician and the patient worry about potential complications, particularly harmful neurologic outcomes. Optimizing certain conditions, such as the general health, anemia, and lung function before surgery, can reduce the complication rate [8]. In addition, the total complication rate can be lowered by properly monitoring cardiac, urinary, and spinal cord functioning during operations. Since early detection can allow the neurosurgeon to avoid neurologic issues, the implementation of neuromonitoring to detect functional changes in the spinal cord, particularly in the reversible phase, is crucial [9].

Although the appropriate signal changes were identified in 3.4% of the 1121 MEP/SSEP-monitored scoliosis procedures, there was no long-term neurologic damage in the 2007 article by Schwartz et al. [10].

Since IONM dramatically lowers the danger associated with spine procedures, it is now the norm in the US and many other industrialized nations. Spine surgeons find multimodal IONM to be accurate and comfortable, however, many may not be able to afford it [10].

In spine deformity procedures, MEP monitoring alone is a straightforward, safe, and practical technique, but multimodal IONM is a better approach [5]. The surgeon-directed MEP type of IONM enables the surgeons to complete the surgeries by themselves with little assistance from the patient during surgery. The capacity of the surgeon to evaluate the amplitudes and relate them to the circumstances in the operating room and anesthetic conditions is essential during spinal surgeries [11]. A previous study has shown that IONM was not connected to hospital costs or duration of stay, but was strongly associated with a greater home release and a decreased risk of neurologic sequelae [4].

Other indications for the application of IONM during spine surgeries include tethered cord, injured spinal cord, extramedullary tumors, minimally invasive surgeries, cervical myelopathies, as well as other surgical specialties such as cranial, vascular, and cardiothoracic surgeries. Furthermore, IONM aids in preventing perioperative peripheral nerve damage (PPNI), which is brought on by excessive mechanical pressure, and neck and limb torsion [12].

In addition, IONM remains of particular interest, especially when treating spinal neoplasms, spinal vascular lesions, and correcting scoliosis [13]. However, its usefulness in predicting and minimizing postoperative neurologic impairments in cervical spine surgery is still heavily disputed [14].

Our study showed that MEP was the most commonly used IONM modality, with 91.7% of neurosurgeons reporting using it, followed by SSEP, which was used by 75% of them. Thirty- three percent (33%) of neurosurgeons declared using EEG. Furthermore, we noticed that 25% of neurosurgeons used EMG, while 16% used BAEP. On the contrary, none of the neurosurgeons in our study used VEP.

A previous study found that individuals who underwent surgery while using IONM did not experience any fewer incidents than those who did not. However, there was a tendency for patients with intramedullary lesions to experience fewer neurological episodes [15]. It is important to mention that multimodal IONM is sensitive and specific for diagnosing intraoperative neurologic damage. Despite a favorable outcome in favor of IONM, we think that some spinal procedures, particularly those that carry higher risks for complications, such deformity correction surgery, will still necessitate and require the use of this diagnostic tool by surgeons. With IONM implementation, neurosurgeons can change their surgical approaches, such as reducing deformity repair, distraction/compression, decompression, and skipping the wake-up test, which was frequently used in the past [16]. The same concept remains required for intramedullary tumors, such as lesions without a distinct cleavage strategy, where IONM changes, such as a decline in Motor Evoked Potentials or D-waves, will cause the resection to be stopped, and corrective measures, like warm irrigation and blood pressure monitoring, to be initiated [13].

In our study, half of the neurosurgeons (50%) reported that IONM often provides them with intraoperative information that could be helpful when an alert occurs during spine surgery. Furthermore, more than 80% of neurosurgeons stated that an alert rarely results in a negative outcome or is harmful to the patients. Today, one of the most popular intraoperative spinal monitoring modalities is SSEP monitoring. It is made of cerebral responses produced by peripheral stimulating electrodes, allowing for very reliable monitoring of

Table 5: Significant Studies Reporting Sensitivity, Specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of Various IONM Techniques.

Reference	Year	Design	Type of Monitoring	No. of Cases	Type of Cases	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Clark et al	2016	Retrospective review	MEP	144	Cervical spine: degenerative CSM and CSM of non-degenerative causes	71	94	NA	NA
Hilibrand et al	2004	Retrospective review	SSEP, tcMEP	427	Cervical spine (CSM, OPLL)	tcMEP: 100; SSEP: 25	tcMEP:100; SSEP: 100	NA	NA
Kim et al	2017	Retrospective review	Multi-channel tcMEP, SSEP	200	Anterior cervical spine (ACDF)	80	97	44.4	99.4
Fujiwara et al	2016	Prospective study	tcMEP	160	Open door cervical laminoplasty	NA	NA	NA	NA
Eggspuehler et al	2007	Prospective study	SSEP, MEP, EMG	246	Cervical pathologies	83.3	99.2	NA	NA
Lee et al	2016	Retrospective review	SSEP, tcMEP, sEMG	182	Posterior cervical survey	50	100	100	97
Traynelis et al	2012	Retrospective case series	SSEP, MEP	720	Cervical spine	NA	NA	NA	NA
Ajiboye et al	2017	Retrospective review	SSEP, MEP	15 395	Anterior cervical spine (ACDF)	NA	NA	NA	NA
Nuwer et al	1995	Retrospective review. SRS survey	SSEP	51 263	Variety of pathologies	92	98.9	42	99.9
Quraishi et al	2009	Retrospective review	SSEP, MEP, EMG	102	Scoliosis and kyphosis	100	84	14	97
Pastorelli et al	2011	Retrospective review	SSEP, TcMEP	172	Spinal deformity	100	98	NA	NA
Hamilton et al	2011	Retrospective review; SRS mortality and morbidity database	SSEP, MEP, EMG	108 419	Variety of spinal pathologies	43	98	21	99
Bhagat et al	2015	Retrospective review	SSEP, MEP	354	Spinal deformity	100	93.3	NA	NA
Gunnarsson et al	2004	Retrospective review	SSEP, sEMG	213	Thoracolumbar procedures	sEMG: 100; SSEP: 28.6	sEMG: 23.7; SSEP: 94.7	NA	NA
Sutter et al	2007	Retrospective review	SSEP, tcMEP, EMG	109	Intradural spinal tumors of various types	92	99	NA	NA
Forster et al	2012	Retrospective review	SSEP, MEP	203	Intradural spinal tumors of various types	SSEP: 94.4; MEP: 95	SSEP: 96.8; MEP: 98.9	NA	NA
Korn et al	2015	Retrospective review	SSEP, tcMEP, EMG, D-waves	100	Intradural extramedullary tumors	82	95	82	95
Harel et al	2017	Retrospective review	SSEP, tcMEP, EMG	41	Intradural extramedullary tumors	75	100	100	97
Sala et al	2006	Retrospective review	SSEP, tcMEP, D-wave, EMG	50	Intramedullary spinal cord tumor	NA	NA	NA	NA
Jin et al	2015	Retrospective review	SSEP, mMEP, and fEMG	25	Intramedullary spinal cord tumor	100	91	60	100

Abbreviations: MEP, motor-evoked potential; CSM, cervical spondylosis; NA, not applicable; SSEP, somatosensory sensory evoked potential; tcMEP, transcranial MEP; OPLL, ossification of the posterior longitudinal ligament; ACDF, anterior cervical discectomy and fusion; EMG, electromyography; SRS, Scoliosis Research Society; sEMG, spontaneous EMG; mMEP, muscle motor evoked potential; fEMG, free-running electromyography.

sensory pathways and the identification of perioperative neurologic changes [17]. In fact, SSEPs are continually monitored throughout the procedure, but their interpretation necessitates temporal summation, which can postpone the discovery of a signal shift by up to 16 minutes [18]. Furthermore, there have been numerous instances of false-positive and false-negative outcomes using this method, raising doubts about its suitability for use as a stand-alone monitoring approach [18].

Conversely, MEPs, which are frequently referred to as transcranial MEPs (tcMEPs), as opposed to SSEPs, involve producing a stimulation either at the level of the spinal cord (D-wave) or at the motor cortex [19]. The signal is then peripherally measured by recording electrodes at numerous preset upper and lower extremities muscle groups. As a matter of fact, MEPs enable monitoring and tracking of the corticospinal tract activity during the surgical operations [20]. However, although MEPs have been demonstrated to be reliable for detecting new postoperative impairments, the great sensitivity to inhaled volatile gases limits the administration of normal anesthesia, and necessitates the use of intravenous anesthetic drugs [19]. Additionally, since a triggered stimulus is necessary to register the MEP, continuous ongoing monitoring is unfortunately not possible.

On the other side, EMG, which can be spontaneous or prompted, is a useful tool for neuromonitoring particular nerve roots that are vulnerable to damage during spinal instrumentation [21]. Similar to SSEPs, continuous recording of sEMG has the benefit of providing real-time feedback during the entire procedure. However, neuromuscular inhibition is not allowed in order to have a proper sEMG response. On the contrary, tEMGs are acquired by stimulating the pedicle screws tulip center. The appropriate muscle group's response is then recorded [22].

While each modality has its own intrinsic advantages and weaknesses, as summarized in Table 1, these strategies complement each other, allowing for comprehensive monitoring of the anatomical areas of the spinal cord. As a result, the idea of multimodal intraoperative neurophysiological monitoring (MIONM) has gained acceptance and is now the norm for many surgical procedures. Despite the notable advances in these techniques, the occurrence of false-positive warnings that force the surgical team to take pointless precautions is still sometimes reported [23].

The effectiveness of IONM in spine surgery published in recent years in many studies are summarized in Table 5 [19].

Similar to our findings, we found that the most important reasons for neurosurgeons to use IONM were medicolegal protection in case of development of neurologic complications as well as the prevention of neurologic complications related to decompression, instrumentation, and grafting at a valuable rate. In fact, 50% of neurosurgeons considered these two reasons to be the most important for the implementation of IONM.

Surgeons cited "medicolegal factors" as the most significant in a recent study. The second and third most important factors were "surgeon reassurance" and "I believe it influences patient outcomes" [24]. Furthermore, we noticed in our study that 33.3% and 16.7% of neurosurgeons believed that using IONM modalities was unnecessary due to "neurologic complications occurring outside of the surgical field itself at a valuable rate", and "provision of self-assurance or peace of mind for me during surgery", respectively.

A study by Gruenbauma et al. also demonstrated the need for multimodality neurophysiological monitoring in preventing neurologic damage during spine surgeries. A complete understanding of the range of neuromonitoring modalities, such as SSEPs, MEPs, sEMG, and tEMG, offers a very sensitive and specific diagnostic array for the prevention of neurologic impairments specific to a given spinal level [25].

To maximize the diagnostic use of IONM during spinal operations, it is crucial to understand the advantages and limits of each modality. The effectiveness of this method for preventing neurologic damage is greatly improved by using an interdisciplinary approach to intraoperative monitoring [26]. In summary, we found that more than 80% of neurosurgeons considered IONM modalities to be useful for spinal procedures.

Study Limitation

This study has potential limitations, one of which is the error encountered in sampling the data. Sampling error or selection bias, which was manifested by the sample size, has led to difficulty in identifying significant relationships in the data.

This was due to the limited ability in convincing the neurosurgeons to participate in the study despite the different means of communication that were used in approaching them. An additional challenge was encountered, due to the refusal of the Lebanese Society of Neurosurgeons to cooperate in the study. This society was approached as an official body involving all the neurosurgeons working in Lebanon but was not cooperative in forwarding the questionnaire to the targeted physicians. Moreover, various institutions were approached to assist in achieving the second part of the study. This step was essential for the determination of the particular relation between the specific modality used for neuromonitoring and the outcome of patients who underwent spine surgeries. However, the institutions that we have contacted were not cooperative in accepting us to review the data and analyze it. This limitation was a huge obstacle that prevented us from advancing in the second part of this study.

Study Perspectives

Longer-term research is required to examine the health and financial advantages of IONM. An increasing corpus of research is showing how effective IONM is at identifying unfavorable outcomes from spinal surgery. The choice of surgeon and regional institutional rules and guidelines govern the use of IONM in the absence of prospective trials with high-level evidence to support its efficacy. The therapeutic role of IONM in spine surgery requires additional research. Large prospective observational cohort studies are required because prospective studies intended to evaluate the effectiveness of post-IONM alert therapies are highly unlikely to be conducted in the future due to ethical constraints and medico legal considerations. Finally, there are still no evidence-based methods for responding to alarms in MIONM, which leaves a major knowledge vacuum in the management both during the event and afterwards. Future research is therefore required to investigate novel therapies, summarize prior information, and create clinical practice guidelines.

Conclusion

The use of IONM to spot warning indications of postoperative neurological sequelae and impairments is quite beneficial. With its high specificity and sensitivity, IONM offers objective parameters that the surgeon can use to reassess the surgical plan and the placement of surgical tools, preventing the development of long-term brain injury. Dialogue, interdisciplinary teamwork, and knowledge of the interdependence between the anesthesiologist, the surgeon, and the neurophysiologist are necessary for the effective use of IONM and the prevention of neuronal injury. In order to select the best strategy and maximize the quality of the readings while maintaining the physiological and hemodynamic conditions, the anesthesiologist should be familiar with the proposed surgery, be able to recognize the different types of IONM to be used and comprehend the influence of medications and anesthetic techniques on neuronal activity.

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