Intradural Extramedullary Spinal Tumor treatment Modalities Using Intraoperative Neurophysiological Monitoring

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Abstract

Background: Intradural extramedullary tumors (IDEMs) are treatable and the surgical goal is a total resection. Intraoperative neurophysiological monitoring (IOM) may be valuable to achieve a radical resection during surgery for IDEMs in two ways. Firstly by confirming the physiological integrity of neural pathways during uneventful procedures. Secondly, by detecting a neurological injury in time for corrective measures to be taken, before an irreversible damage occurs. The use of IOM during surgery for intramedullary spinal cord tumors (ISCT) has become a standard. Vice versa, the utility of IOM for IDEMs has not yet been clearly confirmed. Objective: To improving outcomes of patients with intradural extramedullary spinal tumors. Conclusion: The use of intraoperative neurophysiological monitoring lead to better neurological outcomes at discharge and follow-up.

KeyWords: Intradural extra medullary, IONM, Neurophysiological Monitoring.

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Introduction

Intraoperative neurophysiological monitoring (IONM) could be considered a valid tool to detect in time, during the procedure, the occurrence of a neurological injury, then being able - potentially - to suggest both corrective measures to surgeons and to predict clinical outcomes in a short and long term follow-up[1].

The growing interest for IONM in spinal surgery has been described by Sala, which documented the increasing number of publications and scientific meetings dedicated to this topic through the last years[2].

Furthermore, to strengthen this aspect, the importance of IONM in spinal surgery was corroborated and enhanced later by Class I evidence in the available Literature[3]. That said, only few papers have been able to really enrich evidence about the role of IONM in IDEM tumor surgery[4-6].

Moreover, the heterogeneity of available studies in terms of methods and monitoring modalities (e.g., the use of D-waves vs. non-use) have often made questionable any conclusion about the therapeutic role of IONM[4]. As about surgical technique, minimally invasive approaches have been thought to potentially reduce the magnitude of surgery. While for degenerative disease or bone tumors in spine surgery the use of minimally invasive approaches showed to be effective and feasible in multiple examples Cofano et al[7], Marengo et al[8] for IDEM tumors surgery evidence are few. The use of mono lateral laminectomy, indeed, and the use of technological tools such as the Cavitational Ultrasonic Surgical Aspiration (CUSA) should need for further investigations in order to add relevant data and report surgical experiences[9].

Also, Ghadirpour et al[10] found that to assess neurological functions during surgery, electrophysiological monitoring is a standard procedure in intramedullary tumors. In extramedullary neoplasms, surgery for small and dorsally located tumors does not need electrophysiologic monitoring since the risk of harming the spinal cord is minimal. However, in large or ventrally located tumors, electrophysiologic monitoring may be very useful for intraoperative decision-making and for the prediction of neurologic outcome.

The function of the dorsal columns is easily monitored by somatosensory

evoked potentials (SSEP), which are bilaterally induced at the tibial nerve. In case of cervical tumors, these potentials also can be evoked by stimulation of the median nerve, which leads to more stable responses with shorter latencies[11].

Motor-evoked potentials (MEP) by transcranial electrical or magnetic stimulation of the motor cortex allow monitoring of the function of the corticospinal tract. However, since MEP monitoring leads to mass movements of the stimulated musculature, it only can be applied discontinuously, in contrast to SSEP. In extramedullary tumors, MEP monitoring may be helpful in ventral locations[12].

An important method for monitoring nerve root function during surgery of a

cervical or cauda equina NST is electromyographic (EMG) recording by single muscle electrodes, which allows (1) identification of single nerve roots and (2) monitoring of the current functional status of the nerve. Analogous to intramedullary tumors, special care is taken in tumors compressing the conus medullaris. In these cases, any of the electrophysiological methods could be very helpful. An overview of the monitoring strategy for large tumors dependent on the tumor location is shown in Table (1) [13].

Table (1): Monitoring strategy depending on tumor location[13] .

	Cervical	Thoracic	Lumbosacral	Conus medullaris
SEP	++	++	(+)	++
EMG	++	–	++	++
MEP (ventral locations)	+	+	(+)	++

++ important, + helpful, – unnecessary

Single-method IONM approaches have proven to be insufficient in assessing both the ascending and descending pathways Sutter et al[14], a realization that led to the introduction of multimodal neurophysiologic monitoring. This integration of monitoring methods has significantly enhanced the contribution of complementary monitoring techniques to preservation of patient nerve function integrity following spinal Sutter et al[14], aortic Weigang et al[15], or intracranial Szelenyi et al[16] procedures. Such methods allow for comprehensive identification of iatrogenic neurological injuries at early, reversible stages. Additionally, these methods are also employed as mapping tools to identify sensory and motor neuroanatomy to enable a more selective surgical approach that circumvents crucial functional anatomy and reduces the risk of permanent neurological complications.

The high sensitivity and specificity of intraoperative monitoring have been key factors in establishing its central role in maximal resection of intramedullary spinal cord tumors with minimal compromise of nerve capacity and improved patient outcomes[17]. The first formal historically controlled report presenting improvement of neural outcome due to IONM-monitored intramedullary spinal cord tumor removal described a mean 0.28 increase in McCormick functional grade, in contrast to a mean 0.16 decrease among unmonitored patients[18].

Thus, IONM has evolved into an important adjunct to such surgical procedures, improving overall safety. Despite the significant advances in IONM techniques and applications, their employment in extramedullary-intradural spinal cord tumor resection procedures is highly underestimated and has not been adequately addressed. While extramedullary-intradural removal under multimodality IONM has not been universally adopted as a standard, many centers with IONM services use the methodology routinely. For this reason, a more systematic analysis of multimodality IONM for extramedullary-intradural tumor removal is necessary[19].

The role and value of IONM in spinal surgery may differ according to surgical and pathological context. For example, in theory, IONM may be more helpful during surgery for intramedullary spinal cord astrocytomas as opposed to cauda equina lesions or extramedullary intradural lesions. Therefore, in centers with limited technical, logistical, and financial resources, prioritization often guides the use of IONM. However, in addition to personal experience, intrainstitutional investigations and conclusions regarding the importance of monitoring in different types of surgery, external published literature is of prime importance. For tumor surgery, IONM may also influence oncological factors in addition to prevention of iatrogenic injury. For example, if intraoperative monitoring leads to limitation or abortion of the procedure, it could affect the future of tumor regrowth and worsen the natural course of the oncological disease. Therefore, quantification of and familiarity with the clinical predictive values is of utmost importance for specific disease contexts[19].

Regarding the influence of IONM on extent of resection, in Korn et al[19] series there were nine documented cases in which changes in evoked potential monitoring led the surgeon to perform a subtotal resection, defined for their purposes as a residual tumor ≤5 % of preoperative tumor volume. Four of these patients presented intraoperative changes in either SSEP or tcMEP data, which contributed to a more conservative approach and eventual subtotal resection. Three of these patients presented with neurological deterioration in the immediate postoperative period, with two showing persistent functional declines of 1 degree on the McCormick scale at discharge; however, at long-term evaluation, no patient was left with a permanent deficit in comparison with their preoperative status. It is quite possible that this would not have been the case had IONM not influenced the surgeon to perform a more conservative resection.

Conclusion:

The use of intraoperative neurophysiological monitoring lead to better neurological outcomes at discharge and follow-up, but no associations were found with the extent of resection.

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