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Intraoperative neurophysiological monitoring for intradural extramedullary tumors: Why not?

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ABSTRACT

Background: While intraoperative neurophysiological monitoring (IOM) for intramedullary tumors has become a standard in neurosurgical practice, IOM for intradural extramedullary tumors (IDEMs) is still under debate. The aim of this study is to evaluate the role of IOM during surgery for IDEMs.
Methods: From March 2008 to March 2013, 68 patients had microsurgery with IOM for IDEMs (31 schwannomas, 25 meningiomas, 6 ependymomas of the cauda/filum terminalis, 4 dermoid cysts and 2 other lesions). The IOM included somatosensory evoked potentials (SEPs), motor evoked potentials (MEPs), and – in selected cases – D-waves. Also preoperative and postoperative neurophysiological assessment was performed with SEPs and MEPs. All patients were evaluated at admission and at follow up (minimum 6 months) with the Modified McCormick Scale (mMCs).
Results: Three different IOM patterns were observed during surgery: no change in evoked potentials (63 cases), transitory evoked potentials change (3 cases) and loss of evoked potentials (2 cases). In the first setting surgery was never stopped and a radical tumor removal was achieved (no stop surgery group). In 3 cases of transitory evoked potentials change, surgery was temporarily halted but the tumors were at the end completely removed (stop and go surgery group). In 2 more patients the loss of evoked potentials led to an incomplete resection (stop surgery group). No patients presented a worsening of the pre-operative clinical conditions (at admission 47 patients presented mMCs 1–2 and 21 patients mMCs 3–5, while at follow up 62 patients are mMCS 1–2 and 6 patients mMCs 3–5).
Conclusions: In our series significant IOM changes occurred in 5 out of 68 patients with IDEMs (7.35%), and it is conceivable that the modification of the surgical strategy – induced by IOM – prevented or mitigated neurological injury in these cases. Vice versa, in 63 patients (92.65%) IOM invariably predicted a good neurological outcome. Furthermore this technique allowed a safer tumor removal in IDEMs placed in difficult locations as cranio-vertebral junction or in antero/antero-lateral position (where rotation of spinal cord can be monitored) and even in case of tumor adherent to the spinal cord without a clear cleavage plane.

1. Introduction

The tumors found in the intradural extramedullary compartment are: meningiomas, nerve sheath tumors (schwannomas and neurofibromas), metastases, dermoid tumors, teratomas, paragangliomas, ependymoma of the cauda equina or filum terminalis and hemangioblastomas [1]. They represent 30% of all spinal tumors [2]. The most common primitive intradural extramedullary tumors are meningiomas and nerve sheath tumors (schwannomas and neurofibromas) [3].

Intradural extramedullary tumors (IDEMs) are treatable and the surgical goal is a total resection [1]. 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

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Table 1
Modified McCormick Scale (mMCs) for neurological evaluation of patients with IDEL.

Modified McCormick Scale (mMCs)	
Grade	Definition
I	Neurologically intact, ambulates normally, may have minimal dysesthesia
II	Mild motor or sensory deficit, patient maintains functional independence
III	Moderate deficit, limitation of function, independent w/external aid
IV	Severe motor or sensory deficit, limit of function w/a dependent patient
V	Paraplegic or quadriplegic, even if there is flickering movement

corrective measures to be taken, before an irreversible damage occurs [4].

In 1937, Penfield and Boldrey published a paper [5] about the systematic exploration of the cerebral cortex establishing the conditions for the development of IOM. After Penfield, except for the use of neuromonitoring in epilepsy surgery, almost half a century passed without significant developments in the IOM. In 1972 the somatosensory evoked potentials (SEPs) were introduced by Nash and his group to assess the functional integrity of the spinal cord during surgery [6]. However, according to the first report published in 1986 by Lesser et al. [7], several studies reported cases of post-operative para- or tetraparesis/plegia despite SEPs preservation [8,9]. These studies showed the inability of SEPs in monitoring the anterolateral column, typically damaged in patients with anterior spinal artery syndrome.

In 1990s the introduction of motor evoked potentials (MEPs) elicited by transcranial electrical stimulation (TES) for monitoring of corticospinal motor pathway has dramatically improved the IOM value and reliability. The combined use of epidurally recorded D wave and motor evoked potentials from limb muscles has proved to be a valuable predictor of post-operative motor outcome in patients harboring intramedullary spinal cord tumors (ISCTs) [10,11]. In this regard, a few studies on ISCTs surgery have shown that the loss of muscle MEPs in the presence of a D-wave preserved up to 50% of its baseline amplitude, will result in only transient motor deficits [10,11].

The use of IOM during surgery for ISCT has become a standard [4,12,13]. Vice versa, the utility of IOM for IDEMs has not yet been clearly confirmed [14]. The aim of our study is to assess the usefulness of IOM in the treatment of IDEMs. To the best of our knowledge, no studies have been undertaken so far focused only on the use of IOM for IDEMs.

2. Methods

2.1. Patient population

From March 2008 to March 2013 clinical and IOM data of 68 patients presenting with IDEMs were prospectively collected in a data base and retrospectively analyzed. Neurological status on admission and at follow-up was assessed using the Modified McCormick Scale (Table 1) [15]. Sex, age, Modified McCormick Scale (mMCs) on admission, preoperative neurophysiological evaluation with SEPs and MEPs and tumors localization are summarized in Table 2. The pain was the most common presenting symptom among patients with IDEMs (51%), followed by gait ataxia (18%), motor weakness (12%), sensory deficits (8%) and sphincter disturbances (2%).

The diagnosis of IDEMs was performed for all patients by magnetic resonance imaging (MRI) study (1.5 Tesla), with and without contrast. At the follow-up, all patients had a post-operative MRI, an assessment of the mMCs grade, as well as a neurophysiologic evaluation with SEPs and MEPs.

Table 2
General data, tumors location, preoperative neurophysiological evaluation and Modified McCormick grade on admission.

General data, lesion location, preoperative neurophysiological evaluation and modified McCormick grade on admission	
Age (years)	
Average (range)	57.2 (17–80)
Gender	*n* (%)
Male	23 (33.83%)
Female	45 (66.17%)
Total	68
Lesions location (N %)	*n* (%)
Skull-Cervical Junction	5 (7.35%)
Cervical	11 (16.18%)
Thoracic	37 (54.42%)
Lumbar	15 (22.05%)
Total	68
Preoperative SEPs–MEPs (N %)	*n* (%)
Normal	12 (14.65%)
Pathological	56 (82.35%)
Total	68
Modified McCormick grade on admission	*n* (%)
I	20 (29.41%)
II	27 (39.70%)
III	18 (26.47%)
IV	2 (2.94%)
V	1 (1.48%)
Total	68

2.2. Intraoperative neurophysiological monitoring (IOM)

Our standardized protocol for IOM includes: preoperative, intraoperative and postoperative SEPs and MEPs, intraoperative D-waves (in cervical and thoracic lesions), electromyography (EMG) and bulbocavernosus reflex for cauda or filum terminalis procedures. For stimulation and recording, the ISIS system was used (Inomed Co., Emmendingen, Germany). During surgery IOM was subdivided into: post-induction baseline, intraoperative period and closure. A brief description of our protocol follows.

2.2.1. SEPs

SEPs were elicited by stimulation of the median nerve at the wrist and the posterior tibial nerve at the ankle (intensity, 40 mA; duration, 0.2 ms; repetition rate, 4.3 Hz). Recordings were ensured via corkscrew-like (CS) electrodes inserted in the scalp at Cz/Fz (legs) and C3/C4/Fz (arms), according to the international 10–20 system of electrode placement.

2.2.2. MEPs and D-wave

As described previously in literature [17,18], TES with multi pulse technique was used to elicit muscle MEPs and a single TES stimulus was applied to elicit a D-wave. TES with multi pulse technique includes short trains of 5 square-wave stimuli (single pulse duration, 0.5 ms; interstimulus interval, 4 ms, at a rate of 2 Hz) through CS electrodes placed at C1/C2 (lower limb) and C3/C4 (upper limbs) scalp sites, according to the 10–20 system. A constant current stimulator with a maximum output of 200 mA was applied. MEPs were recorded via needle electrodes inserted into upper and lower extremity muscles. We usually monitor muscle MEPs from the abductor pollicis brevis and the extensor digitorum longus for superior limbs and the vastus lateralis, tibialis anterior and the abductor hallucis for inferior limbs. D-wave was monitored in patients harboring tumors in the cervical and thoracic spine. A single TES stimulus of 0.5 ms duration was applied to elicit a D-wave, recorded by an electrode placed in the epidural or