Influence of Tumor Location and Other Variables on Predictive Value of Intraoperative myogenic Motor-Evoked Potentials in Spinal Cord Tumor Surgery

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■ OBJECTIVE: **To study the influence of tumor location (cervical vs. thoracic; extramedullary vs. intramedullary) on predictive value of intraoperative myogenic motor-evoked potentials (iMEP) changes in patients undergoing surgery for spinal cord tumors.**

■ METHODS: **Three hundred patients retrospective data (91 intramedullary) and 209 (intradural extramedullary) with successful iMEP recordings were analyzed. Responses to transcranial electrical stimulation were recorded from the lower limb muscles. Preoperative clinical variables, iMEPs changes, and postoperative neurologic deficits were noted. Associations between categorical variables and outcome were analyzed with the Fisher exact test.**

■ RESULTS: **Of the 300 patients 28 (9.3%) had significant intraoperative worsening of iMEPs. New postoperative deficits occurred in 23 of these 28 patients. False-positive decreases in iMEPs were observed in 5 patients. There was a significant association between changes in iMEP and postoperative new motor deficits ($P \leq 0.0001$). Multivariate analysis showed that patients with changes in iMEP undergoing surgery for thoracic segment tumors, with longer duration of symptoms (>12 months) and older age (≥21.5 years) were more likely to suffer postoperative neurological decline (odds ratio 4.1, $P \leq 0.001$ and odds ratio 5.4 $P \leq 0.0001$, respectively). The sensitivity of iMEPs was 100% and specificity 98.2%. The positive and negative predictive values were 82% and 100%; however, the sensitivity and specificity is similar in thoracic intramedullary (TIM) ($n = 53$) and cervical intramedullary tumors ($n = 38$) (both were 100% and 97%). The positive predictive value was significantly greater for TIM tumors (93% vs. 50%).**

■ CONCLUSIONS: **A strong association was observed between worsening of iMEPs and postoperative new neurological deficits in patients with TIM tumor.**

INTRODUCTION

The use of intraoperative myogenic motor-evoked potential (iMEP) monitoring has become routine during spinal cord surgery. It allows direct, real-time assessment of central nervous system motor pathway function, as opposed to indirect assessment, such as when conventional somatosensory-evoked potential (SSEP) monitoring is used. This direct assessment helps avoid false-negative (FN) results during spinal surgeries that may occur with SSEP monitoring.[1,2] Transcranial electrical stimulation to elicit intraoperative myogenic motor-evoked potentials (TCe-iMEP) is safe in clinical settings, especially during neurosurgery and orthopedic surgical procedures.[3] Findings from a number of studies also support the value of TCe-iMEP monitoring in identifying acute neurologic compromise during spinal

Key words
- Intraoperative monitoring
- Motor-evoked potentials
- Postoperative outcome
- Spinal cord tumors

Abbreviations and Acronyms
C: Cervical
CEM: Cervical extramedullary
CIM: Cervical intramedullary
EM: Extramedullary
FN: False negative
FP: False positive
IM: Intramedullary
iMEP: Intraoperative myogenic motor-evoked potential
IONM: Intraoperative neurophysiological monitoring
MEP: Motor-evoked potential
MIOM: Multimodal intraoperative monitoring
NPV: Negative predictive value
OR: Odds ratio
PPV: Positive predictive value
SSEP: Somatosensory-evoked potential
T: Thoracic
TCe-iMEP: Transcranial electrical stimulation
TIM: Thoracic intramedullary

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cord surgery for different pathologies and predicting the occurrence of subsequent postoperative neurologic deficits.[4]

Kothbauer et al.[5] assessed the efficacy of TCe-iMEPs and reported that 100% sensitivity and 91% specificity can be achieved in predicting postoperative motor deficits in spinal cord intramedullary (IM) tumor-removal surgery. Nevertheless, in patients with preexisting motor deficits, it may be difficult or even impossible to obtain iMEPs.[6-8]

Although the efficacy of motor-evoked potential (MEP) monitoring in spinal cord surgery is well accepted, it is not known whether the monitoring is effective uniformly in predicting postoperative motor outcome in all patients with spinal cord tumors irrespective of their location (e.g., cervical [C] vs. thoracic [T]; extramedullary [EM] vs. IM) and clinical variables, such as age, duration of symptoms, and functional grade of the patient. We investigated this query in a large series of 300 patients with successful iMEP recordings.

METHODS

Patient Population

We retrospectively reviewed data from 335 consecutive patients who underwent surgery for spinal cord tumors between 2004 and 2013 and were considered for iMEP monitoring. We could not elicit iMEP responses from 35 patients, so they were excluded from the analysis. Hence, data from 300 patients with successful baseline recordings were analyzed. On the basis of our previous experience with the feasibility of obtaining iMEPs, since 2010 we have stopped routine iMEP monitoring in patients with preoperative functional status of Nurick grades 4 and 5 and lower limb power of 0/5 to 2/5.[7] This discontinuation has improved our success rate in obtaining baseline iMEPs in patients with spinal cord tumors. Patient age ranged from 10 to 73 years (mean 38 ± 15 years). There were 207 male and 93 female patients.

Clinical Assessment

Patient's functional status was recorded with the Nurick grading system as indicated: Grade 0 indicates signs or symptoms of root involvement but without evidence of spinal cord disease; Grade 1 indicates signs of spinal cord disease but no difficulty in walking; Grade 2 indicates slight difficulty in walking but does not prevent full-time employment; Grade 3 indicates difficulty in walking that prevents full time employment or the ability to do all housework, but that is not so severe as to require assistance in walking; Grade 4 indicates able to walk only with someone else's help or with the aid of a frame; and Grade 5 indicates chair bound or bedridden. Postoperatively, all the patients were assessed clinically at the end of eighth day. For the purpose of analysis patients were divided into two groups. Postoperative weakness in any single monitored muscle was taken as deterioration and those patients were pooled into one group. Any improvement or same in clinical status was considered as same and those patients were pooled together as one group.

Spinal Cord Tumor Location and Pathology

The location of the tumor was IM in 91 (C, 38 patients and T, 53 patients) and intradural EM in 209 (C, 59 patients and T, 150 patients). The spinal cord tumor was located in the C level (C1—C7) in 96 patients and in the T level (T1—L1) level in 204 patients.

Electrophysiology and Transcranial Electrical Stimulation

Transcranial electrical stimulation was performed with D185 (Digitimer Ltd., Welwyn Garden City, UK) and recording was performed with Viking IV or Endeavour (Nicolet Biomedical Inc, Madison, Wisconsin, USA). Stimulation was delivered by placing an anode (2 cm silver disc) at Cz' (1 cm behind the Cz position) and a cathode at Fpz (electroencephalogram 10—20 electrode system). A train of 5 pulses (50-μs pulse width duration) with a 2-ms interstimulus interval time between them was termed as a "sweep." Five such sweeps were delivered at 0.7 Hz, and responses were averaged. After intubation a gauze piece was placed as bite block to prevent tongue bite. Stimulus intensity was started at 100 V and gradually increased in steps of 10 V until all muscles undergoing monitoring were recruited or until no perceptible patient movement was noticed. A schematic illustration of the stimulating and recording electrode positions used by us is shown in Figure 1.

iMEPs were recorded bilaterally from the following muscles: tibialis anterior, soleus, quadriceps, external anal sphincter, and extensor digitorum brevis. Compound muscle action potentials were recorded with a pair (5 cm apart) of uninsulated subcutaneous needle electrodes. The time base was set at 100 ms and the filter band pass was 30—500 Hz.

Anesthetic Management

Thiopentone (mean dose 240 ± 25 mg, range 68—280 mg) was administered for the induction, and anesthesia was maintained with isoflurane (end-tidal 0.7%) in 218 patients (propofol at 6 mg/kg/hr added in 82 patients), supplemented by O_2 and air in a 1:2 ratio. Fentanyl bolus was used as analgesia intravenously at a mean dose of 174 ± 16 μg (range, 60—380 μg).

Neuromuscular Blockade

Vecuronium (in 269 patients) or atracurium (in 31 patients) was used as a neuromuscular blockade to facilitate tracheal intubation and ventilation. Supplementary doses were given by an infusion titrated to induce 2—3 clearly visible twitches on stimulation of a peripheral nerve (posterior tibial nerve at ankle or median nerve at wrist). Vecuronium infusion was used in the range of 0.055 ± 0.006 mg/kg/h, and atracurium was used in the range of 0.20 ± 0.07 mg/kg/h.

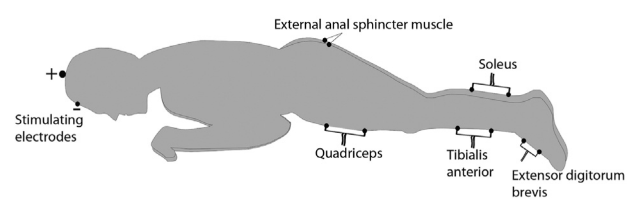

Figure 1. Schematic illustration of the stimulation and recording electrode positions for recording compound muscle action potentials from different muscles.