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Technical Notes & Surgical Techniques

Intraoperative neurophysiological mapping & localization of posterior median sulcus during intramedullary spinal cord tumor resection_technical communication

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ABSTRACT

Objectives: To assess orthodormic stimulation mapping technique for posterior median sulcus with some variation in parameters from that used in Simon study model.

Methods: A Case study of 51 years old female patient diagnosed with intramedullary lesion in the cervical segment, the patient was assigned for laminectomy, tumor exploration and biopsy.

We used custom made bipolar stimulator for mapping; it allows variable flexible distance stimulation along the longitudinal axis of the posterior columns and recording from cortical somatosensory evoked potentials SSEPs C3-Fpz and C4-FPz and Cz-FPz channels. We used lateralization rather than phase reversal in localization of posterior median sulcus.

Results: We were able to identify the functional median sulcus with lateralization to contralateral side rather than phase reversal, the mapping was helpful method to identify PMS, which corresponded to the proposed radiological image's location.

Conclusion: Bipolar orthodormic stimulation can be done using lateralization rather than phase reversal technique. Using Higher Repetition Rate and intensity between 2 and 3 mA can decrease time needed to store averages without compromising evoking the potentials. Stimulation Intensity above 5 to 6 mA can stimulate motor tracts as well in cervical region.

1. Introduction

Dorsal columns (DCs) mapping [2,3] can be done by using one of the following techniques:

One of the first techniques described for spinal cord recording involved placement of a recording electrode on the exposed spinal cord while stimulating from the posterior tibial nerve at the ankles, the largest amplitude responses obtained will be located lateral to the physiologically inert or silent midline, creating the ideal location for the myelotomy to be [performed] [1].

Dorsal column mapping can also be done retrograde, as antidromic sensory nerve action potentials can be obtained by stimulating the spinal cord and recording from a peripheral nerve [4,6].

The method that we used in this case study of dorsal column mapping involves orthodormic stimulation of the spinal cord that is recorded at the scalp by regular SSEPs scalp electrodes with particularly using lateral points like C3′ and C4′.

2. Objective

This case report is to illustrate a direct dorsal column tracts stimulation technique to identify the PMS prior to performing myelotomy, with swollen spinal cord and unclear anatomical landmark.

To describe and assess the technique with some variation in parameters from that used in previous studies, also to do parameters analysis to build upon for future recommendations (see Table 1).

3. Case discussion

Patient is 51 years old female radiologically diagnosed with

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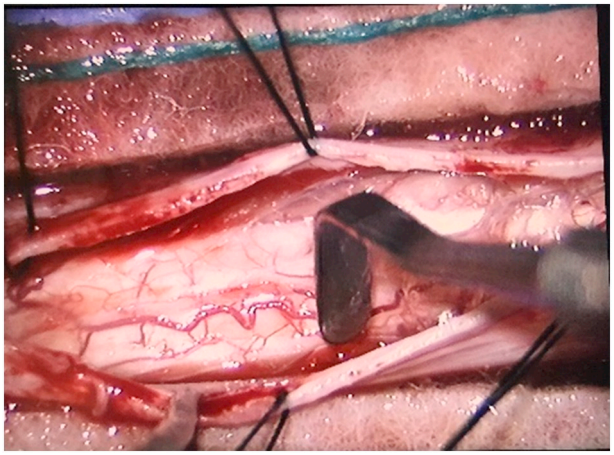

Fig. 1. Spinal cord tumor exposed for mapping before resection.

Fig. 2. Custom made bipolar stimulator.

Fig. 3. Response on C4'- FPz channel when stimulated left side ascending tracts.

intramedullary lesion in the cervical segment, she has no neural deficits, motor and sensory functions are intact with normal sphincters control, the patient was reserved for laminectomy, tumor exploration and biopsy, and was anesthetized using (TIVA) Total intravenous anesthesia of Propofol and fentanyl and positioned in a prone position.

We used the mapping technique as a part of multimodality protocol of Somatosensory Evoked Potentials (SSEPs), Motor Evoked Potentials (MEPs), Electromyography (EMG), to monitor the functional integrity of the Long tracts by means of posterior tibial nerve and median nerve SSEPs and MEPs. We used needles electrodes inserted in the belly of the monitored muscles for spontaneous, Triggered EMG and MEPs recordings, also used corkscrews as Transcranial stimulator (TCS) for MEPs, we used bite block as we routinely do with MEPs stimulation.

Electrodes were placed in Tibialis anterior, extensor halluces longus muscles, and hand muscles for MEPs recording bilaterally, the equipment used is Cadwell cascade elite machine, Stimulation Repetition Rate (RR) was adjusted to 4.13 and number of trials to store average was set to 50 in regular evoked potential montage.

Recording electrodes consisted of corkscrews electrodes which were positioned to obtain the following channels; (Cz′ - FPz) (C3′ - FPz) (C4′ - FPz), each trial took 10 s to be averaged and saved, the stimulation intensities ranged from one mA and going up to 9 mA. Eventually stimulation was set to 2.5 mA which gave reasonable, replicable and monitorable responses in amplitude and morphology.

Once the surgeon opened the dura as in (Fig. 1), we gave him a custom-made bipolar stimulator.

We used two unipolar fixed to bipolar forceps handle as shown in (Fig. 2). The stimulation was done to Dorsal Columns (DCs) longitudinally with anode caudally positioned starting from most lateral available point on the exposed dorsal DC to midline, then crossing to other side.

Surgeon was asked to keep the stimulator in place for 10 s, counting from 1 to 10, for each saved trial needed, then minimally move medially in a distance equal to width of the stimulating brass probe around 1 mm.

We started on the exposed left side of the DCs that gave responses as in (Fig. 3) and then gradually moved to assumed central line then crossed to the right side as shown in trail number 5 (Fig. 4), process was repeated back and forth to confirm silent midline as shown in trial number 3 (Fig. 4).

Normally the stimulation of the sensory tract on the left side should give an upward deflection wave when recording from the contralateral sensory cortex (or downward if we reversed the recording electrodes)

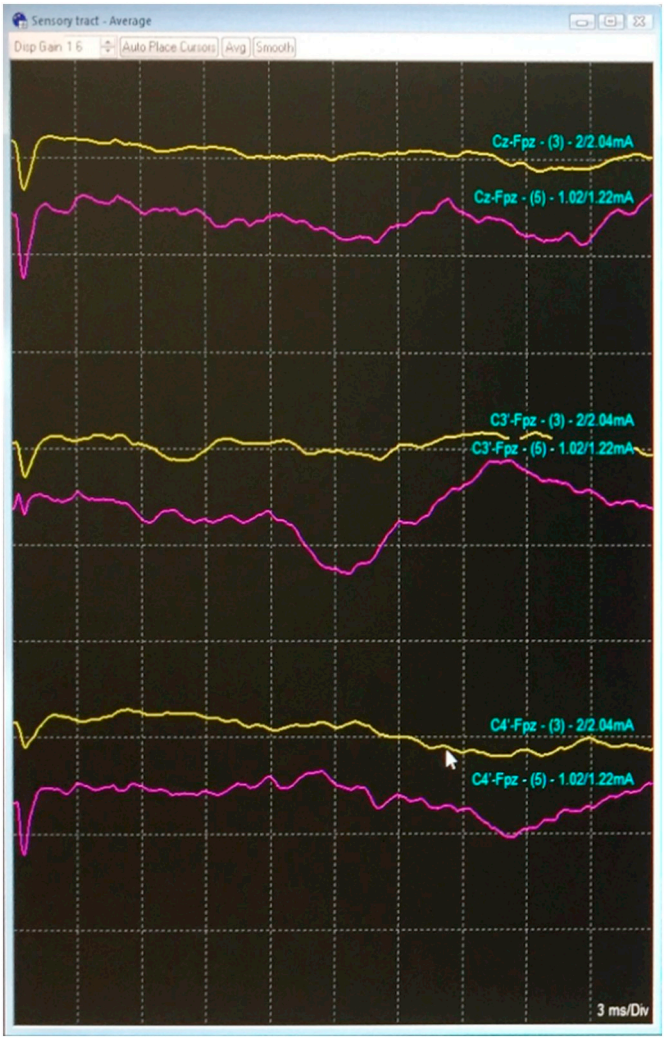

Fig. 4. Medline stimulation gives no response (silent mid line).

which we see in C4-Fpz channel in (Fig. 3) (and vice versa for the write side tract stimulation). If we were stimulating in the midline, neither tracts should be stimulated and no polarity changes would be recorded from either side of the cortex as shown in Fig. 4.

Lateralization of traces were obvious with higher amplitude in (C4′ - FPz) channel when stimulated on the left side of the posterior columns and vice versa, traces were recorded in every possible longitudinal plane stimulation until disappeared in a silent central line, which was anatomically recognized as posterior median sulcus.

Stimulation along the exposed PMS in caudal and cranial directions were tried to assure extension along the field, after crossing the PMS, we were able to record traces again starting at (1 m amp.) on (C3′ - FPz) as we were stimulating the right DCs.

The following table compares parameters used in KFMC Case study and Simon model [2,5]

4. Caveats

The technique need to be tried in multiple patients and in other regions of spinal cord beside cervical.
The Distance between the two points of stimulation may be changed and may affect results.
Small amplitude signal ipsilateral may be noticed due to non-crossing fibers.
Cervical region stimulation may result in co-activation of the neighboring fasciculus Cuneatus results in interference of potentials [2].

5. Results

- Successfully identified the PMS as a central silent line and corresponded with the expected anatomical and radiological PMS.
- Myelotomy was done and biopsy was taken with no residual neurological deficits.

6. Conclusion

1. Utilization of bipolar stimulator can be helpful in identifying and mapping the posterior median sulcus before performing midline myelotomy.
2. Bipolar orthodormic stimulation can be done using lateralization rather than phase reversal technique.
3. Higher Repetition Rate and intensity between 2 and 3 mA can help to decrease averages and consequently time needed for each stored trial.
4. Reponses can be obtained with stimulation intensity starting at 1 m amp, but optimum at 2.5 m amp, if we increase above 4–5 m amp we stimulate the motor tracts (especially because we are in cervical region) as well causing motor contractions and patients movement similar to MEPs.

Financial disclosure

- The authors have no financial interests in the techniques described.

Declaration of Competing Interest

- We received materials used and Intraoperative-monitoring supplies from National Neuroscience Institute (NNI), King Fahd Medical City (KFMC). No other grants or specific funding was needed for the case study.
- The authors declare no conflict of interest.

Table 1
Comparison between stimulations' parameters used in Simon's model of mapping and KFMC case study.

Parameters	Anterograde cortical somatosensory evoked potentials (Simon) [5]	KFMC Case study
Stimulus type	Bipolar probe or 8-microelectrode (1-mm inter-electrode distance)	Forceps-handle bipolar (Flexible inter-electrode distance)
Intensity	Start 0.2 mA up to 2 mA	Starting 0.5 mA and up to 9 mA
Pulse width (μs)	300	200
Frequency (Hz)	3.17	4.13
Recording	Cortical channels CP3–CP4	C3-FPz &C4-FPz
Low-frequency filter (Hz)	30	30
High-frequency filter (Hz)	500	500
Number of averages	200–400	50
Comparison	Phase reversal (relies on the change in polarity)	Laterality (relies on contralateral channel recording)

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