Intraoperative neuromonitoring using motor evoked potential with direct cortical stimulation for lower limb region

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ABSTRACT

Introduction: Transcranial motor evoked potentials (Tc-MEPs) and somatosensory evoked potentials (SSEPs) have been used together for monitoring to prevent motor paralysis in the lower limb region. However, it is difficult to evaluate Tc-MEPs in the lower limb region accurately due to the limited placement of the stimulating electrodes. In this study, we report a direct cortical stimulation motor evoked potential (D-MEP). The identification of central sulcus by SSEPs using a 6-pole strip electrode placed in the interhemispheric fissure to assess motor function in the primary motor cortex of the lower limb. The primary motor cortex was then stimulated using that 6-pole strip electrode placed and MEP was measured.
Intraoperative neuromonitoring (IONM) with D-MEP and SEP during craniotomy for brain tumors in the lower limb region was performed in 21 surgical cases of 18 patients from December 2018 to August 2022. IONM was performed with Tc-MEP from the beginning of surgery, and after dural opening, a 6-pole strip electrode was implanted in the interhemispheric fissure after dissection. Then, central sulcus was identified, and the electrodes were used to stimulate the primary motor cortex of the lower limb. Anesthesia was performed under total intravenous anesthesia. The baseline MEP waveform was defined as a reproducible waveform of 30 μV or greater, and a warning was defined as a significant decrease in amplitude of 50% or greater, observed continuously.
The success rate of the identification of central sulcus in the lower limb region was 76.2% (detected in 16 of 21 cases). In all 21 cases, there was no significant decrease in amplitude due to direct injury of corticospinal tract, and no new lower extremity paralysis appeared postoperatively. The D-MEP may be a reliable tool for monitoring motor function in the lower limb region.

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BACKGROUND

- In neurosurgery, transcranial motor evoked potentials (Tc-MEPs) and somatosensory evoked potentials (SEPs) were used together for monitoring to prevent motor paralysis in the lower extremity region.
- We report the results of a 6-pole strip electrode placed in the interhemispheric fissure on the surgical side and in he primary motor cortex of the lower extremity region, and the identification of the central sulcus by SEP and monitoring by direct cortical stimulation motor evoked potentials (D-MEP).

· Brage L, et al. Direct cortical stimulation with cylindrical depth electrodes in the interhemispheric fissure for leg motor evoked potential monitoring. Clinical neurophysiology. 2020.
· Yuich Maruta Masami Fujii et.al.; Intra-operative monitoring of lower extremity motor-evoked potentials by direct cortical stimulation . Clinical neurophysiology. 2012

METHODS AND MATERIALS

1. Intraoperative neuromonitoring (IONM) with D-MEP and SEP during craniotomy for brain tumors in the lower limb region was performed in 21 surgical cases of 18 patients from December 2018 to August 2022.
2. IONM was performed with Tc-MEP from the beginning of surgery, and after dural opening, a 6-pole strip electrode was implanted in the interhemispheric fissure after dissection. Then, central sulcus was identified, and the electrodes were used to stimulate the primary motor cortex of the lower limb. Anesthesia was performed under total intravenous anesthesia. The baseline MEP waveform was defined as a reproducible waveform of 30 μV or greater, and a warning was defined as a significant decrease in amplitude of 50% or greater, observed continuously.
3. compound muscle active potentials (CMAPs) were bilaterally recorded by placing electrodes on the skin over the abductor pollicis brevis (APB), tibialis anterior (TA), gastrocnemius (Gc), and abductor hallucis longus (AH). Tc-MEP recording was considered to be successful when the recorded amplitude of CMAPs was more than equal 30 μV.
4. Maintained under total intravenous anesthesia Muscle relaxants only during intubation

SUGERY DETALIS AND SETTING CONDITIONS

MEP : Motor evoked potential

Filter : 2～3KHz

- Addition : once (5 train stimulations) (suprathreshold stimulation: stimulation at threshold +20% increase)
- ISI:Inter Stimulus Interval : 1.5msec～2.0msec
- pulse width : (constant voltage : 0.05msec, constant current : 0.2～0.5msec)
- Analysis Time : 50～200msec

D-MEP : Direct MEP

- 6-pole strip electrode Stimulus setting conditions are the same as for MEP
- Stimulus intensity: 30 mA (suprathreshold stimulation: stimulation at threshold +20% increase)

RESULTS

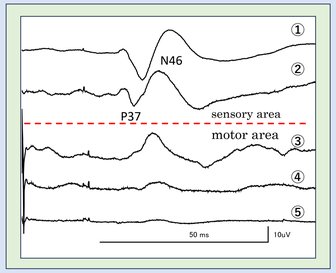
Patient nubmer	Age	Sex	R/L	Location	Pathology	Indentification of LE SEP	D-MEP of LE	D-MEP of LE stimulus intensity (mA)	D-MEP of LE amplitude (μV)	preop MMT of affected LE	MMT 1M of affected LE	MMT 3M of affected LE
1	67	F	R	parietal	glioblastoma	NA	○	21	302	1	2	3
2	55	F	R	frontal	brain metastasis	NA	○	27	135	4	5	5
3	60	M	L	frontal	glioblastoma	NA	○	12	30.3	5	5	5
4	47	F	R	parietal	glioblastoma	○	○	22	119	4	4	4
5	56	F	R	frontal	brain metastasis	○	○	25	568	5	5	5
6	72	M	L	frontal	glioblastoma	○	○	26	505	5	5	5
7	48	F	R	parietal	glioblastoma	NA	○	37	95	3	3	3
8	63	F	R	frontal	glioblastoma	○	○	30	489	4	5	5
9	78	F	R	parietal	meningioma	○	○	25.9	457	5	5	5
10	65	F	R	frontal	brain metastasis	○	○	25	841	5	5	5
11	84	M	R	frontal	meningioma	○	○	13.5	343	5	5	5
12	68	F	L	frontal	meningioma	○	○	5	670	5	5	5
13	72	F	L	frontal	meningioma	○	○	3	846	5	5	5
14	58	M	L	parietal	oligodendroglioma	○	○	10	920	4	5	5
15	70	M	R	frontal	meningioma	○	○	30	61	5	5	5
16	62	M	R	frontal	brain metastasis	○	○	25.4	230	4	5	5
17	71	M	L	frontal	brain metastasis	○	○	30	32	4	3	4
18	46	M	L	frontal	intracranial melanoma	○	○	15	98	5	5	NA
19	53	M	L	frontal	brain metastasis	○	○	27	104	5	5	5
20	40	F	L	frontal	glioblastoma	○	○	23	292	5	5	5
21	48	M	L	frontal	glioblastoma	NA	○	18	1250	3	4	4

LE:lower extremities NA:not available MMT: Manual Muscle Test

Table 1. CHARACTERITICIS OF THE PATIENTS WITH D-MEP OF LOWER EXTREMITIES AND SEP

CONCLUSIONS

1. Strip electrode placement in the primary motor cortex of the lower limb in the interhemispheric fissure enabled central sulcus identification and lower limb monitoring with D-MEP.
2. It was suggested that D-MEP could be a reliable monitoring.



Tibial nerve stimulation
Stimulus Intensity : 25-45mA
Configuration: SSEP
Bandpass : 10 - 20Hz ～ 1.5K - 3KHz

Figure 1. Identification of the central sulcus was confirmed by phase-reversal waveforms between 2 and 3 caused by tibial nerve stimulation.

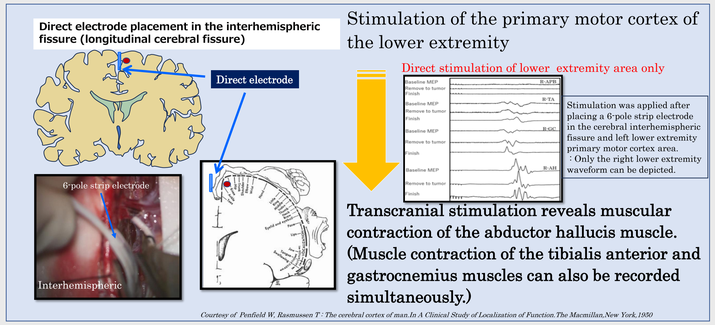


Figure 2. 6-pole strip electrode placed Location

DISCUSSION

1. Stable contralateral lower extremity monitoring was possible with D-MEP in all cases.
2. In 16 of 21 cases, central sulcus identification was possible. (Central sulcus identification detection rate: 76.2%) In previous reports, phase inversion of the tibial nerve SEP is generally not obtained. (MacDonald 2019, Brage L et.al 2020) 。Although localization of the tibial nerve SEP was reportedly dependent on the amplitude of maximal P37, we were able to identify the central sulcus by tibial nerve stimulation in the present study.
3. Tc-MEP could be recorded as well, but CMAP waveforms of the upper and lower extremities were derived simultaneously.