MOTOR EVOKED POTENTIALS AND TRANSCUTANEOUS MAGNETO-ELECTRICAL NERVE STIMULATION

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The purpose of this study was to identify the mechanism of cerebral cortex human isometric contraction information processing. By using transcutaneous magneto-electrical nerve stimulation technique, musculi flexor crapi radialis/ulnaris isometric contracts, the nerve digitals palmares/volares communes nerve mediani/ulnaris were stimulated. The results showed that many evoked potential amplitude of gyrus postcentralis and praecentralis, lobules parietals superior and inferior, gyrus temporaries' superior/medius/inferior are significantly different to each other. Some peak absolute latency and interpeak /interwave latency, either sensory or motor was shorter in the same side hemisphere, while those in the opposing side hemisphere were longer. The above results indicated that the sensory afferent information occurred previously in the same side hemisphere rather than the opposing hemisphere.

KEY WORDS: neurometrics, brain electrical activity mapping, isometric contracting

INTRODUCTION: It has been established that human nerve cells can be stimulated non-invasively with externally applied time-varying electromagnetic fields. The stimulation can be achieved either by directly driving current into the tissue (electrical stimulation) or by means of electro-magnetic induction (magnetic stimulation). This equipment, namely the magneto-electric stimulator (MES) has been approved for cortical or cervical stimulation, specifically for use in deep peripheral nerve stimulation. The technique is noninvasive and therefore very useful for studying higher brain functions such as cognition. Since it is possible to investigate the functions and structure of the brain by applying localized and Victoria magnetic stimulation to targets in the cerebral cortex, magnetic stimulation is expected to become an increasingly important method in the field of brain research. While the electrical stimulation of the peripheral neuromuscular system has many beneficial applications, peripheral magnetic stimulation, so far only has a few. Transcutaneous magneto-electrical nerve stimulation (TMENS) of the motor cortex has been used to evaluate the corticospinal pathways in different neurological diseases. Somatosensory evoked potentials (SEPs) are well-established diagnostic tools to assess brain function in patients who have been diagnosed with these diseases. Motor potentials evoked by TMENS may provide objective information about the central motor pathways. Except for a few reports of MEP in coma, brain death or in-patients with locked-in syndrome, MEPs have not been systematically employed in an intensive care setting up to now.

METHODS: Position of Electrodes: International 10-20 System. Electrode Application: Ten 20 conductive EEG paste. Montages: Bipolar (Interface impedance ≤3Ω). Reference electrode: A1A2 (impedance≤2). Following stimulation of the median nerve at the wrist, neural responses are recorded over large nerve bundles in the sensory parietal cortex. Evoked potential signals clinically evaluate the integrity of various segments of the sensory or motor-conducting pathways. The latency of EP voltages changes measures firsthand the conduction velocity and the amplitude changes are shown beside the functions. Voltages for various EPs range from approximately 0.1 to 100μV. In the paper, negative voltage is plotted upward for SLSEP, while positive voltage is plotted downward. Negative peaks are labeled N and positive peaks are labeled P. The current convention is to number EP components sequentially or to label them by their typical latency.
When left hand received transcutaneous magneto-electrical nerve stimulation and quiet (null) left (L) hand muscle flexor crapi radialis/ulnaris produced isometric contractions (handset 2.5 kg dumbbell) recording evoked potential amplitude (μV) and different(ms) ③right (R) hand musculi flexor crapi radialis/ulnaris isometric contractions recording evoked potential

amplitude (μV) and different(ms) among same bipolar. Equipment: CADWELL spectrum 32 magneto-electric stimulator: CADWELL MES-10.
This study involved the investigation of cortical excitatory and inhibitory systems, using the technique of transcutaneous magneto-electrical nerve stimulation. Stimuli were applied with a circular coil. The circular coil delivered the conditioning stimulus with the intensity set at 80% percent power level. Motor-evoked responses to the test stimulus were recorded at the musculi flexor crapi radialis and ulnaris isometric contracted. MEPs for the test stimulus and the control response were recorded first. Polyphonic MEPs with ten negative and ten positive peaks were recorded, labeled as N1, P1, and N10,P10. N1~10 and P1~ 10 peaks amplitudes were calculated. These experimental results suggest that MEPs initiate the excitation of both cortical interneurons and pyramidal tract neurons. Once the pyramidal-tract neurons generated a waveform, the excitation is unaffected by a conditioning stimulus, which has an inhibitory effect on excitability of pyramidal tract neurons.

RESULTS:

Table 1 105ms Sweep Left Musculi Flexor Crapi Radialis/Ulnaris Isometric Contractions Recording 1~10 Peaks Absolute Latency(ms) and Different (ms)

	F4	C4	P4	F8	T3	T5	T6
	L	L		df	df	df	df
LN1	7.44	7.44	7.44				
LP1	10.13	9.98	9.40	0.98	2.20	2.20	1.47
LN2	12.09	15.02	18.45				
LP2	13.80	16.74	21.14	2.44	10.02	6.36	6.85
LN3	15.02	27.98	28.23				
LP3	16.25	31.41	31.16	2.20	6.36	2.44	3.67
LN4	20.16	36.54	47.30				
LP4	22.85	40.21	50.72	1.47	2.44	1.96	2.69
LN5	28.47	47.54	57.32				
LP5	30.92	59.52	59.52	2.20	3.91	3.91	2.20
LN6	33.85	61.23	61.23				
LP6	40.45	63.19	66.37	3.91	4.65	5.62	2.44
LN7	42.41	74.44	68.33				
LP7	44.61	77.13	71.01	1.47	2.20	2.93	4.40
LN8	47.54	81.04	75.17				
LP8	50.23	83.24	78.59	3.67	2.69	3.91	2.44
LN9	60.99	88.86	81.82				
LP9	62.95	91.55	85.44	2.44	7.33	5.13	5.62
LN10	81.04	94.49	89.35				
LP10	83.24	97.18	91.80	1.71	3.67	10.02	5.87
	A	B	C	D	E	F	G
P<0.05	AB		AC		DE	DF	DG

LN1 - 10: 1st, 2, tenth peak negativity latency. LP1 - 10: 1st, 2,tenth peak positively latency.
L: latency (ms). Df: different (ms). Am: evoked potential amplitude (μV)

Table 2 105ms Sweep Same Bipolar When Null and Left Musculi Flexor Crapi Radialis/ Ulnaris Isometric Contracting Recording 1~10 Peaks Absolute Latency (ms) and Different (ms)

	F7 (df) null	F7 (df) L	F3(L) Null	F3(L) L	F3 (Am) null	F3 (Am) L	F4 (L) null	F4 (L) L
LN1			14.78	6.96			14.05	7.44
LP1	6.85	1.96	25.29	11.60	2.80	5.21	24.80	10.13
LN2			27.49	14.78			26.76	12.09
LP2	8.07	1.96	41.92	16.74	3.34	3.47	29.94	13.80
LN3			44.61	18.20			44.12	15.02
LP3	2.20	1.96	45.83	22.85	0.53	4.54	45.59	16.25
LN4			48.28	28.23			47.05	20.16
LP4	2.69	2.69	49.50	32.63	0.53	3.21	51.94	22.85
LN5			53.66	34.10			53.66	28.47
LP5	2.20	4.16	58.30	42.65	1.60	9.48	55.37	30.92
LN6			62.21	45.10			56.34	33.85
LP6	5.38	2.93	68.08	49.99	2.14	6.54	58.55	40.45
LN7			69.79	55.37			61.97	42.41
LP7	7.33	3.18	72.73	59.77	1.20	4.27	64.94	44.61
LN8			74.44	60.75			73.95	47.54
LP8	7.82	2.44	77.62	62.21	2.14	1.74	77.95	50.23
LN9			91.55	74.44			91.55	60.99
LP9	3.18	2.93	94.49	78.11	1.07	3.61	95.22	62.95
LN10			98.40	82.02			98.15	81.04
LP10		3.91	102.07	83.97	1.34	5.21	101.82	83.24
	A	B	C	D	E	F	G	H
M	5.08	2.81	61.05	44.02	1.67	4.73	58.69	36.22
SD	2.52	0.78	24.22	24.89	0.93	2.12	25.21	22.29
P<0.05		AB		CD		EF		GH

Table 3 Evoked Potential Amplitude (μV) of when Left Hand Transcutaneous Magneto-electrical Nerve Stimulation and Right Hand Musculi Flexor Crapi Radialis/Ulnaris Isometric Contracting Recording Evoked Potential Amplitude of 1~10 Peaks

	T6 Am	F8 Am	P3 Am	T3 Am	C4 Am	F3 Am	F7 Am	C3 Am	F4 Am
LN1									
LP1	2.67	0.80	1.20	2.00	4.27	1.34	1.20	1.60	2.17
LN2									
LP2	1.60	1.60	2.14	1.87	1.74	3.07	2.00	2.67	2.14
LN3									
LP3	1.47	1.20	1.60	1.87	3.47	2.94	2.14	3.34	2.14
LN4									
LP4	4.01	2.00	2.00	3.21	2.14	1.34	2.27	1.47	1.87
LN5									
LP5	3.87	2.00	1.07	2.14	7.16	3.74	5.21	2.40	4.54
LN6									
LP6	3.07	2.00	1.87	2.54	1.34	1.60	4.54	1.07	3.74
LN7									
LP7	0.93	1.34	1.07	1.07	1.47	4.01	3.07	1.20	3.34
LN8									
LP8	2.14	1.20	1.34	1.07	1.34	1.47	1.20	0.53	1.60
LN9									
LP9	1.60	1.20	0.93	2.14	1.47	2.27	3.87	0.80	2.27
LN10									
LP10	1.74	1.60	1.34	1.87	3.07	1.34	1.47	1.07	2.14
M	2.31	1.49	1.46	1.98	2.74	2.31	2.70	1.61	2.60
SD	1.05	0.42	0.42	0.63	1.86	1.05	1.42	0.90	0.95
	A	B	C	D	E	F	G	F	H
P<0.05	AB		CD		CE	CF	CG	FH	

Table 4 When Left Hand Transcutaneous Magneto-electrical Nerve Stimulation and 1)null 2) left (L) hand 3) right (R) hand Musculi Flexor Crapi Radialis/Ulnaris Isometric Contractiving Recording Evoked Potential Amplitude (μV) and Different(ms) among Same Bipolar

	N□T6 Am	R□T6 Am	N□F4 Am	R□F4 Am	L□F4 Am	L□F3 Am	R□F3 Am	L□F3 df	R□F3 df
LN1									
LP1	1.07	2.67	2.14	2.17	2.27	5.21	1.34	4.65	1.47
LN2									
LP2	3.74	1.60	1.60	2.14	0.93	3.47	3.07	1.96	2.20
LN3									
LP3	0.93	1.47	0.80	2.14	0.93	4.54	2.94	4.65	2.20
LN4									
LP4	4.45	4.01	1.47	1.87	1.87	3.21	1.34	4.40	1.47
LN5									
LP5	2.94	3.87	1.07	4.54	1.87	9.48	3.74	8.56	1.96
LN6									
LP6	4.94	3.07	3.34	3.74	3.34	6.54	1.60	4.89	3.42
LN7									
LP7	4.54	0.93	2.14	3.34	1.34	4.27	4.01	4.40	4.89
LN8									
LP8	2.8	2.14	1.74	1.60	2.14	1.74	1.47	1.47	1.96
LN9									
LP9	3.61	1.60	1.74	2.27	1.60	3.61	2.27	3.67	3.42
LN10									
LP10	2.80	1.74	1.34	2.14	1.07	5.21	1.34	1.96	1.47
	A	B	C	D	E	F	G	H	I
M	3.18	2.31	1.73	2.60	1.73	4.73	2.31	4.06	2.45
SD	1.37	1.05	0.70	0.95	0.74	2.12	1.05	2.04	1.12
P<0.05	AB		CD		DE	FG		HI	

DISCUSSION: In order to investigate motor-nerve functions, MEPs were recorded from the peripheral muscles that responded to transcutaneous magneto-electrical nerve stimulation of the target cortex area that innervates the corresponding muscles. The results suggest that both the stimulation points affects peripheral muscle response to magnetic stimulation of the cortex and the direction of induced eddy current. When a transient current flows through a coil exterior to the wrist, time-varying magnetic fields are generated in the brain. The time-varying magnetic fields in the brain. MEPs are useful for noninvasive investigation of dynamic connections of neurons in the cortex. An optimal direction of stimulating induced currents for neuronal excitation exists in each functional area of the cortex. These vectorial characteristics in EPs reflect, in part, anatomical and functional organization of the neurons and neuronal fibers of the brain. The introduction of nerve-excitation models has widened our understanding of the mechanisms of nerve excitation elicited by magnetic stimulation. The theoretical nerve excitation models have shown that for neuronal excitation, a negative peak of the spatial gradient of induced electric fields, the activating function, contributes to the depolarization of the membrane. The site of neuronal excitation corresponds to the site of the maximal value of the activating function. Neural responses are recorded over large nerve bundles in the sensory and motor parietal cortex.

Latencies of EPs responses vary significantly between different sensory modalities, requiring different recording parameters for various EP tests. Since the background EEG and other unwanted signals often appear irregular, or do not synchronize to EP stimuli, averaging markedly reduces them. Exposure to magneto-electric stimulation produces a series less than 5μV in amplitude when recorded from the EEG. Such low amplitude responses cannot be detected following a single magneto-electric stimulation or even after averaging 16 magneto-electric stimulation's responses. Averaging 100 or more trials, however, demonstrates brain activity associated with magneto-electric stimulation processing.

Although many EPs are generated by postsynaptic potentials, the latency of the EPs largely determined by the rate of action potentials conducted along fast-conducting myelinated axons. Large myelinated axons conduct action potentials rapidly by salutatory conduction; that is , action potentials jump along nodal gaps between myelinated segments. Evoked potential recording. Important biophysical principles in recording EPs include the concepts of EP generators, near- and far-field recording, and dipole models. Evoked potential generators. Compound action potential and post-synaptic potentials generate the EPs over peripheral nerve and white matter tracts in the spinal cord and brain. The EPs over fiber tracts consist of localized potential gradients called near-field potentials and more broadly distributed far-field potentials. Near-field potentials are usually recorded as triphasic waves and are thought to represent traveling from compound action potentials propagated along fiber tracts. Electrodes must be placed adjacent to the neural sources to detect the steep potentials. Far-field potentials have broader fields that are detected by electrodes placed farther from the anatomic source. Far-field potentials appear to measure variations in local geometry that produce impedance changes such as when a fiber tract exits a tissue compartment. Like EEG, EP signals in cortex are due to summated postsynaptic activity from clusters of related neurons called generators. Neuron action potentials are larger than postsynaptic action potentials, but poorly synchronized and rapid (1500/s) and are usually not detected by the macro-electrodes used for clinical EP recording.

CONCLUSION: Some peak absolute latency and interpeak /interwave latency of sensory or motors were short in the same side hemisphere, opposite side hemisphere were longer. The above results indicated that the sensory of proprioceptive afferent information previously occurred in the same hemisphere rather than in opposite hemisphere,

REFERENCES:

Schwarz, S., Hacke, W., & Schwab, S. (2000). Magnetic evoked potentials in neurocritical care patients with acute brainstem lesion. *Journal of the Neurological Sciences*, **172**, 1-30

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