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Original Article

Movement-related cortical potential in patients with acute stroke

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Abstract

Aim

To identify the pattern and side of brain plasticity following acute stroke in patients who recovered and assess motor upper limb function using motor-related cortical potentials.

Patients and methods

Eleven patients diagnosed with acute ischemic stroke were recruited from in patients and stroke clinic within Ain Shams University Hospital. They were assessed after 2 or more weeks from stroke onset and showed power in finger flexors and extensors of two or more according to Medical Research Council; their motor recovery was assessed by using Fugal–Meyer scale. A high-density 64-channel electroencephalogram connected to an event-related potential software detector is used to record motor-related cortical potential by asking the patient to press on a bottom for an average of 130 presses with a free interval of 3–5 s between each press using the index finger of the paretic hand. Motor potential epoch component was filtered and analyzed regarding amplitude and latency using event-related potential lab within a MATLAB software programmed for analyzing event-related potentials with particular attention to lateralized readiness potentials along cortical areas of interest.

Results

A total of 11 adult patients completed the study. Three (75%) patients with right-side weakness had potential from the intact side, and one (25%) patients had potential from the lesion side. Six (86%) patients with left-side weakness had potential from the intact side, and one (14%) patients had potential from the lesion side. There was a weak nonassociation between the source of potential and the side of weakness (Cramer's $V = 0.13$, $P = 0.65$).

Conclusion

This study investigated brain activity changes during movement intention and execution of index movement using comprehensive EEG analysis method, which combined indicator mammalian ependymin-related proteins (MERPs) and choroidal neovascularization (CNV) time-frequency mapping. EEG changes in time and time-frequency domains showed different topographical features and might provide comprehensive information for studying movement disorders such as those in a poststroke patient.

Keywords: Electroencephalography, evoked potentials, hemiparesis, recovery of function, stroke

Introduction

Recovery that emerges and continues after 2–3 weeks from stroke onset has been attributed to neuroplasticity, a structural and/or functional reorganization of the brain in response to internal or external environmental stimuli, in which functions previously performed by the ischemic area appear to be resumed by either ipsilateral or contralateral brain areas [1].

Neuroplasticity also means the brain's ability to reorganize itself by forming new neural connections throughout life. Neuroplasticity allows the neurons in the brain to compensate for injury and disease and to adjust their activities in response to new situations or changes in their environment.

It has been variously attributed to the availability of redundant parallel distributed pathways, changes in synaptic strength, axonal sprouting with the formation of new synapses, the

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assumption of function by contralateral homologous cortex, and substitution of uncrossed pathways [1].

Cortical reorganization and functional recovery of paretic limbs after an ischemic cerebrovascular accident have been successfully demonstrated through different diagnostic and investigational tools including transcranial magnetic stimulation, positron emission tomography, and functional MRI as well as through monitoring electrical brain activity [2,3].

The event-related potential (ERP) is the measured brain response that is the direct result of a specific sensory, cognitive, or motor event. More formally, it is any stereotyped electrophysiological response to a stimulus. The study of the brain in this way provides a noninvasive means of evaluating brain functioning in patients with cognitive and/or motor disorders [4].

Movement-related cortical potentials recorded with EEG can be divided into two main components: potentials occurring during intention or anticipation of an upcoming movement, which is also called Bereitschafts potential for self-paced potentials [5], and motor potential, occurring at the time of execution [6].

During 1998, Green and colleagues perfomed a study to recorded movement-related cortical potentials with left and right finger movements in 10 patients with varying degrees of recovery after hemiplegic stroke. By using a new modality of 128-electrode high-resolution ECG to detect reorganization of cortical motor control, they noticed that reorganization of cortical motor control takes place after stroke, which may involve ipsilateral or contralateral cortex depending on the site and size of the brain lesion, and theoretically, the somatotopic organization of the residual pyramidal tracts [7].

It is assumed that studying motor-related potentials in poststroke hemiparetic patients will supply neuroscientists with knowledge regarding the specific site of functional neuroplasticity regarding localization as well as lateralization aiding in decision making regarding further neurorehabilitation techniques.

Aim of the work

The aim was to identify the pattern of brain plasticity following acute stroke in a patient who had recovered motor upper limb function using motor-related cortical potentials and to identify the side of recovery ipsilaterally or contralaterally.

Patients and methods

(1) Study design: an observational cross- sectional study was done to assess the movement-related cortical potential of patients with postacute ischemic hemiparesis owing to first-ever cerebrovascular ischemic stroke. Ethical Committee approval was taken
(2) Patients: a total of 11 patients after two weeks from onset of the first-ever cerebrovascular ischemic stroke were recruited.

Criteria for selection

Inclusion criteria

The following were the inclusion criteria: age ranges between 18 and 70 years, both sexes, first-ever ischemic cerebrovascular stroke with motor deficit, and follow-up assessment after 2 or more weeks from onset shows power in finger flexors and extensors of two or more according to the Medical Research Council.

Exclusion criteria

Hemorrhagic stroke, recurrent cerebrovascular stroke, severe hemihypesthesia or sensory loss, apraxia, fluent, and/or global aphasia were the exclusion criteria.

Methods

All patients were subjected to written consent describing the aim as well as the methods applied within the study. All patients were subjected to careful history taking based on the stroke sheet approved and applied within the Stroke Unit of Neurology Department, Ain Shams University. Routine stroke protocol investigations are done in the Stroke Unit of the Neurology Department. All patients were subjected to full neurological examination including National Institute of Health Stroke Scale. All patients were subjected to Fugal–Meyer assessment form for sensorimotor recovery after cerebrovascular stroke. All patients were subjected to a high-density 64-channel electroencephalogram connected to an event-related potential software detector within the neuromodulation laboratory at the neurology department of Ain Shams University.

Statistical analysis

Descriptive statistics of mean, SD, frequency, and range values were utilized in presenting the patients' demographic and variables data. The association between the source of potential and the side of weakness was analyzed using the χ^2 test of association with Cramer's V tests. Five percent level of probability was used to indicate statistical significance. All statistical measures were performed through the statistical package for social studies (SPSS), version 22, for Windows (IBM SPSS, Chicago, Illinois, USA).

Results

Patient characteristics

Muscle power

The median grade of muscle power at the onset of the lesion was 2 with minimum and the maximum value of 0 and 3, respectively; however, at time of examination, it was 3, with minimum and the maximum value of 3 and 4, respectively (Tables 1 and 2).

National Institute of Health Stroke Scale

The median grade of National Institute of Health Stroke Scale was 1 with a minimum and the maximum value of 0 and 3, respectively (Table 2).

Female/male

The mean ± SD female/male was 61.18 ± 2 with a minimum and the maximum value of 58 and 65, respectively (Table 2).

Source of potential

Three (75%) patients with right-side weakness had potential from the intact side, and one (25%) patients had potential from the lesion side. Six (86%) of patients with left-side weakness had potential from the intact side, and one (14%) patients had potential from the lesion side. There was a weak nonassociation between the source of potential and the side of weakness (Cramer's $V = 0.13$, $P = 0.65$) (Table 3).

Table 1: The mean±SD age, sex, and side of weakness distribution of the study group

	Total (n=11)
Age	
Mean±SD	49.73±11.24
Range	34-75
Sex [n (%)]	
Female	5 (45.5)
Male	6 (54.5)
DM [n (%)]	
No	10 (90.9)
Yes	1 (9.1)
HTN [n (%)]	
No	3 (27.3)
Yes	8 (72.7)
Other [n (%)]	
No	7 (63.6)
Yes	4 (36.4)

DM, diabetes mellitus; HTN, hypertension.

Table 2: Descriptive statistics of muscle power and National Institute of Health Stroke Scale and Fugal-Mayer of the study group

	Total (n=11)
Muscle power [n (%)]	
G3	6 (54.5)
G4	5 (45.5)
NIHSS	
Median (IQR)	1 (0-2)
Range	0-3
F/M	
Mean±SD	61.18±1.99
Range	58-65

F, female; IQR, interquartile range; M, male; NIHSS, National Institute of Health Stroke Scale.

Table 3: Distribution of source of potential in the study group

Side of weakness	Positive (intact side) [n (%)]	Negative (lesion side) [n (%)]	χ^2	P
Right	3 (75)	1 (25)	0.19	0.65
Left	6 (86)	1 (14)		
Total	9 (82)	2 (18)		

Discussion

The present study examined recovered hemiparetic patients' MRPs after cortical infarction. High-resolution EEG coregistered with MRI is capable of identifying reorganization of motor control in stroke patients with recovered hemiparesis. This may involve the ipsilateral hemisphere, or there may be relocation in the contralateral hemisphere [8].

The motor potential is defined as the area under the curve between movement onset and peak negativity; the implantation of a motor task measured over primary motor cortex is preceded by a low decrease in the EEG.

MERPs comprise three events during motor task called readiness potential, motor potential, and movement monitoring potential.

We recorded EEG from multiple electrodes including C1and C2 [9], to identify the abrupt increase of the gradient.

Main recording location for MERCPs is C3, CZ, and C4 [10].

We filtered the collected EEG data, from eye artifact and muscle artifact. In our study, we used EEG to detect MERPs from the collected EEG data in the study. We noticed negative signal in the event-related potentials not only on one side but also from another side during movement, but the more negative event-related potential indicates the side of recovery.

In this study, we used event-related cortical potential for a number of patients who recovered from acute cortical ischemic stroke, to describe the side of brain organization.

The study showed that 75% of patients with right-side weakness had potential from the contralateral side of the lesion, and 25% patients had potential from the ipsilateral side of the lesion.

Contralateral reorganization was found in six (86%) patients of the patients with left-side weakness. By clinical assessment of this patient, muscle power at the time of examination ranged from three to four according to Medical Research Council, and one (14%) patient of left-side weakness patients had potential from ipsilateral side.

Conclusion

Movement-related cortical potential is allowed frequency shift in EEG recording occurred about 2 s before voluntary movement production. Brain reorganization in patients with acute comes from both ipsilateral and contralateral hemispheres. According to the study, in most cases with acute stroke, recovery potential comes from the contralateral side.

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Conflicts of interest

There are no conflicts of interest.

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