Original Research

Effect of Anodal Transcranial Direct Current Stimulation to Flexor Digitorum Superficialis Muscle Activities in Stroke Subjects

Ana Mursyida[1,2*], **Reni H. Masduchi**[3,4], **Imam Subadi**[3]

[1]*Faculty of Medicine, Universitas Airlangga,Dr. Soetomo Academic General Hospital, East Java, Surabaya, Indonesia*
[2]*Widodo Hospital, Ngawi, East Java, Indonesia*
[3]*Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo Academic General Hospital, Surabaya, East Java, Indonesia*
[4]*Department of Physical Medicine and Rehabilitation, Jemursari Islamic Hospital, Surabaya, East Java, Indonesia*

*Corresponding Author:
Ana Mursyida, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo Academic General Hostital, Jl. Mayjen Prof. Dr. Moestopo No.6-8, Surabaya, East Java, Indonesia
Email: anamursyida27@gmail.com

Article info:
Received: January 29th, 2021;
Received in revised: December 15st, 2021;
Accepted: December 29th, 2021
Published: February 25th, 2022

Cite this as:
Mursyida A, Masduchi RH, Subadi I. Effect of anodal transcranial direct current stimulation toflexor digitorum superficialis muscle activities in stroke subjects. *SPMRJ*. 2022;4(1):21-25.

ABSTRACT

Background: Stroke is the main causes of upper extremity weakness that may affect physicalindependency resulting in long-term disability. Previous studies showed that A-tDCS can improve neurological damage. A-tDCS causes depolarization and induces brain synaptic plasticity in stroke subjects.

Aim: To analyze the effect of A-tDCS to the flexor digitorum superficialis (FDS) muscles activities in stroke subjects.

Material and Methods: This experimental study was conducted from April to September 2020. Eight patients who suffered first attack ischemic stroke, aged 40 to 70 years old, were recruited from PMR outpatient clinic at Dr. Soetomo General Hospital Surabaya. Subjects were randomized into experimental and control group. The control group was given occupational therapy for 30 minutes, while the experimental group was given A-tDCS with intensity 2 mA for 20 minutes and occupational therapy for 30 minutes in 5 consecutive days. Measurement of FDS muscle activities using sEMG were performed before and after intervention in both groups.

Results: There was an increase of FDS muscles activities after treatment in control group (p=0,048) while there was no similar result in treatment group (p=0,188). The change of muscles activities was not different between groups (p=0,974).

Conclusion: tDCS provides no significant benefit in terms of muscle activities in patients with stroke. Small number of samples and other several factors might limit the significancy of current study. Further study is needed to determine the benefit of A-tDCS as a rehabilitation modality in patient with stroke.

Keywords: *flexor digitorum superficialis muscles activities, ischemic stroke, occupational therapy, tDCS*

Introduction

Stroke is a rapid development brain dysfunction characterized with focal and global clinical symptoms lasting for 24 hours or more or causing death without any other cause than vascular. Stroke is the leading cause of long-term disability in the adult population in the world.

Half of the post-stroke patients had damage to the upper extremities in the form of muscle weakness, somatosensory disorders, spasticity and synergistic movements that couldaffect motor control. The results of the Basic Health Research of the Ministry of Health ofthe Republic of Indonesia (RISKESDAS) in 2018 showed an increase in the prevalence of stroke in Indonesia, increasing by 10.9 per 1000 population from 7 per 1000 population in 2013.

Weakness of the upper limb can occur in 60-70% of stroke sufferers, which is an important factor in the reduced ability of a person to use his arms and hands for daily activities.[1–3] Thus far, rehabilitation management iscommonly carried out with occupationaltherapy which aims to facilitate a person's performance by improving relevant performance skills or developing and teaching compensation strategies to address missing performance skills. However, the results of occupational therapy on stroke have not been satisfactory.[4]

In recent years, transcranial direct current stimulation (tDCS) has been used to repair neuropsychological and neurological damage[5]. tDCS is a non-invasive brain stimulation technique which uses stimulator to deliver constant current through electrode positioned above the cranium.[5] Previous study showed thattDCS is able to improve post-stroke rehabilitation outcomes by triggering neuroplasticity mechanisms.[6,7] Anodal-tDCS (A-tDCS) causes depolarization and increases the excitability of the lesion hemispheres,thereby inducing synaptic plasticity in the brainof post-stroke patients.[7] Several studies on A-tDCS were mostly carried out in post-strokepatients and the results of these studies showed significant motor performance improvements.[8,9] Research conducted by Chaet al[10] on stroke patients who were given functional training and tDCS showed a significant increase between pre and post intervention. Furthermore, two systematic reviews on tDCS supported the clinical application of tDCS for post stroke patient due to its minimal adverse effect and high potential in improving recovery.[11,12]

Despite the supporting evidence of tDCS, there is a scarcity of studies that assess the effect of A-tDCS in post-stroke patient on muscle activity of upper extremity using objective measurement tool. Surface Electromyography (sEMG) can provide objective calculation of muscle energy at rest and its changes in movement. The advantage ofsEMG is safe, easy, and non-invasive. Among upper extremity muscles, flexor digitorum superficialis muscle has a very important role in producing a firm grip. Therefore, this study aims to analyze the effect of A-tDCS to flexor digitorum superficialis muscles activities using sEMG in stroke subjects.

Material and Methods

This research was conducted in the rehabilitation outpatient clinic of Dr. Soetomo Academic General Hospital Surabaya from April to September 2020 and has been approved by the hospital ethics committee. The study subjects were recruited from rehabilitation outpatient clinic of Dr. Soetomo Academic General Hospital Surabaya.The total study subjects were 8 patients with inclusion criteria as follow: 1.) first attack ischemic stroke with an onset of 2 weeks to 12 months, 2.) hemiparesis with manual muscletest score of wrist flexor and finger flexor muscle is 2-4 and manual muscle test score of elbow and shoulder flexor muscle is minimal 2, 3.) no range of motion limitation on shoulder, elbow, wrist, and finger joint, 4.) able to understand and follow instruction, 5.) no cognitive disturbance (mini mental state examination score ≥ 24), and 6.) agree to be thestudy subject and follow the protocol by signing the informed consent. The exclusion criteria are as follow: 1.) severe spasticity on upper extremity (modified Ashworth scale ≥

3), pain on upper extremity with Wong Baker pain scale ≥ 4, 3.) hemineglect, 4.) apraxia, 5.) hemianopsia.

Research subjects were randomly divided into control and treatment groups following sequence of number generated by Research Randomizer software.[13] The control group received 30 minutes of occupational therapy for 5 consecutive days. The treatment group received 20 minutes of A-tDCS with intensity 2mA using constant current electrical stimulator (Caputron Activa Dose II, Gilroy, USA) and 30 minutes of occupational therapy for 5 consecutive days. The active anodal electrode was placed on primary motor area (M1) (point C3 or C4 according to the international 10-20 electroencephalogram system) of the affected hemisphere. The reference electrode on the supraorbital region in the contralateral hemisphere. The outcome of this research was flexor digitorum superficialis muscle activity evaluated by using sEMG.

Statistical Package for Social Sciences (SPSS) was used to conduct statistical analysis. Parametric and non-parametric test was usedbased on normality of the data. Baseline characteristics were analyzed by using Fisher's exact test, independent sample t-test, and Mann-Whitney test. Paired T test was used to assess the differences of sEMG result before and after the treatment of both groups. Between group comparison was analyzed by using independent Ttest. P value < 0.05 is considered significant.

Results

No adverse effects of the treatment were reported during or after the treatment. All subjects finished the sessions. No difference of subjects' characteristics was found between the two groups before the treatment in term of age, sex, manual muscle test (MMT) and spasticity. However,the sEMG examination before the treatment showed lower of flexor digitorum superficialis muscle activity in treatment group compared to control group (0.03±0,01 vs 0.11±0,05, p = 0.023). Significant improvement of sEMG value (Δ value) was found after treatment in control group (0.03±0,04, p = 0.023) but no difference of change (Δ value) was found between group (p = 0.974).

Table 1. Demographic characteristic of sample

Characteristic	Group		N	Mean	SD	Nilai p
Age	Treatment		4	51,50	±14,93	0,782*
	Control		4	53,75	±4,35	
Gender	Treatment	Male	1			0,486**
		Female	3			
	Control	Male	3			
		Female	1			
Baseline MMT	Treatment	2	3			0,155***
		3	1			
		4	0			
	Control	2	1			
		3	2			
		4	1			
Spasticity	Treatment	0	0			0,739***
		1	2			
		2	2			
	Control	0	1			
		1	0			
		2	3			
Hemiparesis	Treatment	Dextra	3			0,486**
		Sinistra	1			
	Control	Dextra	1			
		Sinistra	3			

*Independent sample t-test; ** Fisher's Exact test; *** Mann-Whitney test*

Table 2. Baseline Surface EMG delta comparison between control and treatment group

Group	N	Mean (mv/second)	SD	p
Treatment	4	0,03	±0,01	0,023*
Control	4	0,11	±0,05	

* *Independent sample t-test*; Sig: p <0,05

Table 3. Comparison of sEMG before and after intervention in treatment group (Δ value)

sEMG	N	Mean (mV/second)	SD	P
Before	4	0,03	±0,01	0,188*
After	4	0,06	±0,04	

* *Paired sample t-test*; Sig: p <0,05

Table 4. Comparison of sEMG before and after intervention in control group (Δ value)

sEMG	N	Mean (mV/second)	SD	P
Before	4	0,11	±0,05	0,048*
After	4	0,14	±0,05	

* *Paired sample t-test*; Sig: p <0,05

Table 5. Surface EMG Δ value comparison between control and treatment group

Group	N	Mean (mV/second)	SD	P
Treatment	4	0,03	±0,04	0,974*
Control	4	0,03	±0,02	

Independent sample t-test; Sig: p <0,05

Discussion

The average age of patient in this study was 51 years old in treatment group and 53 years old in control group. This finding is in accordance with the previous study that show age as one of non-modifiable stroke riskfactors, it is known that risk of stroke increases after 55 years old.[14] It is known that the incidence of stroke was more in men than women,[14] whereas in this study, it was found that the same number of men and women was found, which can be caused by the limited number of research samples. MMT, spasticity and site of hemiparesis in both groups weresimilar. Therefore, it will not affect the outcome.

Surface EMG (sEMG) examination of flexor digitorum superficialis muscle activity after the treatment showed significant improvement in control groups. However, the change was not significantly different compared to the change in treatment group. This result is not in linewith previous research which showed addition of tDCS results in better improvement of upper extremity motor abilities[9,15,16] and brain functional connectivity[17] that can be influenced by several factors. Firstly, the difference in baseline data of sEMG between the treatment and control groups may affect the rate of improvement. Furthermore, in this study, we did not distinguish the area of the lesion and the specific phase. According to previous studies, analyzing the effects of tDCS in post-stroke patients can be influenced by many biases, including the different characteristics of the patients enrolled as study subjects.[7] Some of the characteristics that need to be specified are lesion areas (cortical and subcortical lesions), etiology (ischemic, hemorrhagic, and lacunar), and phase (acute,subacute, and chronic)[7].

Other factor that may influence the result is the onset of stroke in each group. Treatment group consisted of 1 patient in subacute phase of with onset of 5 months and 3 patients in chronic phase with onset of 7, 9, and12 months, while control group consisted of 1 patient in subacute phase with onset of 2 months and 3 patients in chronic phase with onset of 6, 9, and 12 months. In some theories, it is stated that the optimal motor stroke improvement occurs in the first 6 months after stroke.[18] In contrast with this result, previous study showed that combination of occupational therapy and tDCS significantly improved motor function of patient with stroke in subacute and chronic phase.[16]

No blinding method was used in this study. However, sEMG was used as an

objective outcome measurement tool to minimize bias even though sEMG alsohad drawbacks related to muscle substitution pattern. The neuromuscular system can express the same movements using different muscle groups which may affect the sEMG recording.[19]Another possibility that can occur is the phenomenon of "crosstalk", where the energy from one muscle group moves to the recording plane of another muscle group, so it will be difficult to isolate certain muscle records.[19] Even though in this study the researcher has anticipated by determining the location of the muscles in accordance with atlas of electrode placement and by using small electrodes, the result still needs to be interpreted carefully.

Conclusion

No beneficial effect of tDCS was found in terms of muscle activities to support its use to improve motor function in patients with stroke. Small number of samples and other several factors might limit the significancy of current study. Further study is needed to determine the benefit of A-tDCS.

References

1. Ekstrand E, Lexell J, Brogårdh C. Grip strength is a representative measure of muscle weakness in the upper extremity after stroke. Top Stroke Rehabil. 2016;23:400–5.
2. Hunter SM, Crome P. Hand function and stroke. Rev Clin Gerontol. 2002;12:68–81.
3. Hosseinzadeh SA, Mazhari S, Najafi K, Ahmadi M, Aghaei I, Niazi M, et al. Impact of anodic transcranial direct current stimulation (TCDS) on changes in movement and life–related functions in patients with chronic ischemic stroke: A clinical trial. Entomol appl sci lett. 2018;5:13–20.
4. Steultjens EMJ, Dekker J, Bouter LM, Van de Nes JCM, Cup EHC, Van den Ende CHM. Occupational therapy for stroke patients: a systematic review. Stroke. 2003;34:676–87.
5. Brunoni A, Nitsche M, Loo C. Transcranial direct current stimulation in neuropsychiatric disorders. Cham, CH Springer Int Publ. 2016;
6. Shaheiwola N, Zhang B, Jia J, Zhang D. Using tDCS as an add-on treatment prior to FES therapy in improving upper limb function in severe chronic stroke patients: a randomized controlled study. Front Hum Neurosci. 2018;12:233.
7. Fusco A, Iosa M, Venturiero V, De Angelis D, Morone G, Maglione L, et al. After vs. priming effects of anodal transcranial direct current stimulation on upper extremity motor recovery in patients with subacute stroke. Restor Neurol Neurosci. 2014;32:301–12.
8. Gomez Palacio Schjetnan A, Faraji J, Metz GA, Tatsuno M, Luczak A. Transcranial direct current stimulation in stroke rehabilitation: a review of recent advancements. Stroke Res Treat. 2013;2013.
9. Hordacre B, Moezzi B, Ridding MC. Towards targeted brain stimulation in stroke: connectivity as a biomarker of response. J Exp Neurosci. 2018;12:1179069518809060.
10. Cha H-K, Ji S-G, Kim M-K, Chang J-S. Effect of transcranial direct current stimulation of function in patients with stroke. J Phys Ther Sci. 2014;26:363–5.
11. Bornheim S, Thibaut A, Beaudart C, Maquet P, Croisier J-L, Kaux J-F. Evaluating the effects of tDCS in stroke patients using functional outcomes: a systematic review. Disabil Rehabil. 2020;1–11.
12. Russo C, Souza Carneiro MI, Bolognini N, Fregni F. Safety review of transcranial direct current stimulation in stroke. Neuromodulation Technol Neural Interface. 2017;20:215–22.
13. Urbaniak GC, Plous S. Research Randomizer (Version 4.0) [Internet]. 2013 [cited 2013 Jun 22]. Available from: https://www.randomizer.org
14. DeLisa JA, Gans BM, Walsh NE. Physical medicine and rehabilitation: principles and practice. Vol. 1. Lippincott Williams & Wilkins; 2005.
15. Utomo A, Wulan SMM, Wardhani IL. Effect of short period simultaneous stimulation of transcranial direct current stimulation on occupational therapy to brain-derived neurotrophic factor serum in stroke patients. Syst Rev Pharm. 2020;11:979–82.
16. ŞIK BY, Dursun N, Dursun E, SADE I, ŞAHİN E. Transcranial Direct Current Stimulation: The Effects on Plegic Upper Extremity Motor Function of Patients With Stroke. J Neurol Sci. 2015;32.
17. Lefebvre S, Dricot L, Laloux P, Desfontaines P, Evrard F, Peeters A, et al. Increased functional connectivity one week after motor learning and tDCS in stroke patients. Neuroscience. 2017;340:424–35.
18. O'Brien AT, Bertolucci F, Torrealba-Acosta G, Huerta R, Fregni F, Thibaut A. Non-invasive brain stimulation for fine motor improvement after stroke: a meta-analysis. Eur J Neurol. 2018;25:1017–26.
19. Criswell E. Cram's introduction to surface electromyography. Jones & Bartlett Publishers; 2010.