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Case Report

Transcranial Direct Current Stimulation Improves Pusher Phenomenon

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Keywords
Pusher phenomenon · Transcranial direct current stimulation · Parietal area

Abstract
An 83-year-old man suffered from cerebral infarction of the right middle cerebral artery territory. In association with severe left hemiparesis and hemispatial neglect on the left side, he showed severe pusher phenomenon (PP), which made rehabilitation difficult. Transcranial direct current stimulation (tDCS) was applied to the parietal area (2 mA × 20 min/day; anode on the right and cathode on the left) for 8 days, which resulted in remarkable improvement of PP and caused prolongation of static sitting time. tDCS of the parietal area could be a novel treatment option of PP following stroke.

Introduction

Pusher phenomenon (PP) [1] is a disorder that impairs postural balance following a brain lesion such as a stroke. Those patients lean towards the paretic side actively pushing with the nonparetic arm and leg and resist any attempt of passive correction of the tilted body while sitting or standing. Under the circumstances of PP, rehabilitation promoting ambulation is difficult.

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There have been many studies using neurostimulation such as transcranial magnetic stimulation or transcranial direct current stimulation (tDCS) for rehabilitation following neurological diseases. However, no report investigated the effect of neurostimulation on PP. Here, we report the first case whose PP following stroke improved after tDCS of the parietal area.

Case Report and Intervention

An 83-year-old man suffered from cerebral infarction in the right middle cerebral artery territory (Fig. 1a) of cardiac origin. He presented severe left hemiparesis and hemispatial neglect on the left side. Despite the intensive rehabilitation in the acute phase, he could not maintain upright posture caused by contraversive pushing (Fig. 1b), which made the further rehabilitation difficult. In addition, his Mini-Mental State Examination scored 14, showing that he also suffered from severe cognitive impairment.

After written informed consent was obtained, tDCS intervention was started at 47 days after the stroke. The local ethical committee approved the treatment protocol.

The weak direct current (2 mA) was induced through saline-soaked sponge electrodes (surface 35 cm^2) and delivered by a specially designed battery-driven, constant current stimulator (DC Stimulator Plus; neuro-Conn GmbH, Ilmenau, Germany).

Based on the assumption that dysfunction of the parietal lobe is involved in PP [2], we applied tDCS to the parietal area. Because of interindividual variability of responses, before the treatment session started, three types of test stimulation were tried on separate days, STIM A (anode at right parietal [P4]/cathode at left parietal [P3]), STIM B (anode at P3/ cathode at P4), and STIM C (sham stimulation). Electrode positions were in accordance with the international 10/20 electroencephalogram system. During each test stimulation, the line bisection task and line cancellation task were carried out, and the static sitting time was also measured, for the purpose of determining the appropriate stimulation montage. In this pretreatment session, the line cancellation task significantly improved during STIM A (data not shown). Therefore, we chose STIM A as intervention stimulation.

The stimulation lasted for 20 min each day. The patient underwent tDCS with concurrent physiotherapy for an 8-day intervention period. Physiotherapy during tDCS intervention included sitting training, self-lifting training, and range of motion (ROM) exercise.

Before and after the intervention, the line bisection task and line cancellation task were tested to examine hemispatial neglect, which were repeated 15 and 5 times before and after intervention, respectively. The static sitting time was measured 5 times before and after intervention, respectively. The scale for contraversive pushing (SCP) [3] and Burke lateropulsion scale [4] were also recorded.

Those parameters were compared before and after intervention by Mann-Whitney U test, if appropriate. Statistical analysis was conducted with free software R ver.3.3.2. (https://www.r-project.org/).

Results

The patient did not report any complication related to tDCS.

After the 8-day intervention, static sitting time lengthened significantly (Mann-Whitney U test; $p < 0.03$) (Fig. 2), whereas the line bisection task and line cancellation task did not

improve. SCP improved from 5.5 to 4.25. Berg lateropulsion scale improved from 13 to 8. The patient's sitting posture before and after the intervention is shown in Figure 1b and c.

Discussion

In the present study, tDCS of the parietal area improved PP and caused the prolongation of the static sitting time but not hemispatial neglect.

tDCS can modulate neuroplasticity in the human cerebral cortex noninvasively and painlessly so as to elicit prolonged, but yet reversible, shifts of cortical excitability [5]. tDCS has been applied not only to motor and language function but also higher cognitive function including hemispatial neglect [6–8]. However, there have been no reports documenting that tDCS improved PP.

PP is seen in 9.4% of stroke patients, more on the right hemisphere lesion [9]. In patients with PP, malperfusion of the inferior parietal lobule and parietal white matter was reported [2]. Dysfunction of those areas, to which we applied tDCS, might be responsible for the pathogenesis of PP.

In the present patient, tDCS improved PP but not hemispatial neglect. This divergence of tDCS effects is consistent with a previous study demonstrating that recovery from PP was not related to hemispatial neglect [10].

This report investigated a single patient, so it is uncertain that we can generalize our results. It is also impossible to exclude the possibility that recovery from PP in our patient reflected the natural course. However, the instantaneous recovery just after tDCS in spite of the unsuccessful acute rehabilitation might support our hypothesis of tDCS-induced neuroplasticity. Further study with a crossover design or randomized controlled trial is needed to settle this problem.

Conclusion

tDCS could be a treatment option for PP following stroke.

Statement of Ethics

This study was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. The patient and his family have given their written informed consent to publish their case (including publication of images). The study protocol was approved by the institute's committee on human research.

Disclosure Statement

The authors have no conflicts of interest to declare.

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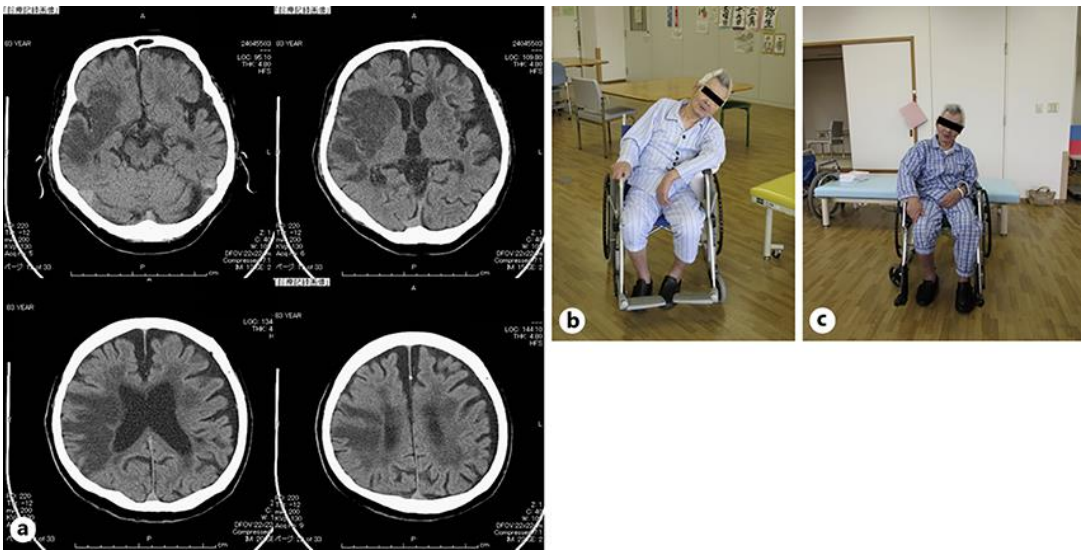

Fig. 1. **a** CT of the brain demonstrating broad infarction of the right middle cerebral artery territory. **b** Sitting posture before tDCS intervention. **c** Sitting posture after tDCS intervention.

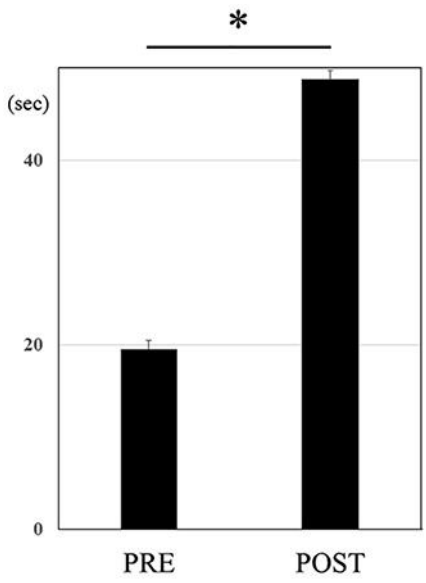

Fig. 2. Static sitting time before and after tDCS intervention. PRE, pre-intervention; POST, post-intervention. * $p < 0.05$.