Improvement of consciousness after transcranial direct current stimulation - a sham-controlled double blind study

9th World Congress on Brain Injury
Edinburgh, Scotland
24 March 2012

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Patients

Introduction | Materials and Methods | Results | Conclusion

Aim of the study

Assessing the effect of transcranial direct current stimulation (tDCS) on consciousness in VS/UWS and MCS patients

double blind sham controlled randomized study
Why direct current stimulation?

<table>
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<tr>
<th>Stimulation</th>
<th>Population</th>
<th>Effects</th>
<th>Authors</th>
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<tr>
<td></td>
<td>Aphasia</td>
<td>Language</td>
<td>Baker et al, <em>Stroke</em> 2010</td>
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- Non-invasive
- Easy to apply
Methods

- Direct current
- 2 mA
- 20 minutes

Randomized double blind sham/placebo controlled
Methods

Responders: CRS-R total score post tDCS > pre-tDCS > sham > pre-sham

Statistics: Stata 10.0
ANOVA
Wilcoxon signed-rank test
Population

- 55 patients (16 women)
- 25 VS/UWS, 30 MCS (18 MCS-/12MCS+)
- aged 43 ± 18 y
- 25 traumatic/30 non-traumatic
- 20 acute/35 chronic (>3 months post insult)
Effect of tDCS

Total (n=55)   Responders (n=17)   MCS (n=30)   VS/UWS (n=25)

*   *   *

CRS-R increase

sham   tDCS
sham   tDCS
sham   tDCS
Effect of tDCS

Total (n=55)  Responders (n=17)  MCS (n=30)  VS/UWS (n=25)

No effect of ethiology or chronicity
Observed improvements

17 responders

- Response to command (n=7)
- Visual pursuit (n=4)
- Object manipulation (n=3)
- Functional communication (n=3)
Conclusion

tDCS improves consciousness in minimally conscious state patients both acute and chronic; traumatic and non traumatic
THANK YOU!
Responders

25 VS/UWS → 2 responders
2/11 VS/UWS acute
0/14 VS/UWS chronic

30 MCS → 15 responders
7/9 acute
8/21 chronic
Neuroimagery

Prefrontal stimulation

- Improvement of DMN connectivity (MRI)
- Increase of regional electrical activity in the PF and AC cortexes (EEG) ($\uparrow \beta$ and $\downarrow \delta/\theta$)

Motor stimulation

- rCBF increase in the left M1, right prefrontal cortex, right S1 (PET-scan)
- Functional connectivity increased within premotor, motor and sensorimotor areas (EEG)

Responders: audition subscale

- Consistent movement to command
- Reproducible movement to command
- Localisation of sounds
- Auditory startle
- None

Comparison between tDCS and sham: PRE vs POST
Responders: motor subscale

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<th>PRE</th>
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<th>tDCS</th>
<th>sham</th>
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<td>Functional use of objects</td>
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<td>Object localization</td>
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<td>Object manipulation</td>
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<td>Localization of noxious stimulation</td>
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<td>Flexion withdrawal</td>
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<td>Abnormal posturing</td>
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Responders: communication

Functional communication

Intentional communication

None

tDCS

sham

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Group data (n=55)

17 responders
- 2 VS/UWS; acute
- 15 MCS; 7 acute/8 chronic

CRS-R

17 responders
- 2 VS/UWS; acute
- 15 MCS; 7 acute/8 chronic

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VS/UWS vs MCS

MCS

* 

VS/UWS

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<td>tDCS</td>
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NS
Status improvement

3 VS/UWS ➞ MCS

- Visual pursuit (n=2)
- Response to command (n=3)

3 MCS ➞ EXIT

- Functional communication (n=3)
- Functional use of objects (n=1)
tDCS presumed mode of action

**Short term effects**
Modification of neuronal excitability (action potential)

**Long term effects**
Action on opening of ion channels ($\text{Na}^+$, $\text{Ca}^{2+}$)
Increase NMDA receptors excitability
$
\iff$
improve neuron excitability

Nitsche et al., J Physiol 2000
Nitsche et al., Neuroscientist 2010
tDCS – advantages

**DBS** and **Amantadine** improve cognitive functions of patients with disorder of consciousness.

But side effects

**tDCS** improve cognition of patients in minimally conscious state without risk of brain damage or seizure.

Schiff et al., Nature 2008
Thibaut et al., in prep
tDCS criticisms

Limitations:

- Short term effect
- Moderate clinical change
- Unknown physiological effects (cathode)
- Improve electrode position?
tDCS parameters and safety

Intensity: 2mA
Time: 20 minutes
Voltage: max 26V
Electrodes: 35cm²
Max: 0.1mA/cm²

\[ U = R \times I \]

2mA et 10kOhm
= 20V OK
2mA and 20kOhm
= 40V STOP