EARLY NON-INVASIVE NEUROPHYSIOLOGICAL INTERVENTIONS IN PATIENTS WITH ACUTE BRAIN OR SPINAL CORD LESIONS

Josep Valls-Sole
Hospital Clínic i Provincial de Barcelona
Jordi Montero Homs
Hospital Universitari de Bellvitge
Hatice Kumru Cam
Institut Guttmann de Neurorehabilitació







NUEVAS VIDAS

1. Objectives

1. Characterize the pathophysiological mechanisms implicated in the generation of spasticity.

2. Analyse the effects of non-invasive early neurophysiological interventions as a treatment for spasticity and other functional consequences of upper motor neuron syndromes.

2. Results

They are divided into 4 sections:

1) Contributions to the increase in knowledge of basic aspects of motor control and sensory perception

I) The effects of transcranial direct current stimulation on perception of nociceptive stimuli applied to the palm of the hand. Westgeest et al. 2014 showed that there is better central nervous system control of nociceptive sensation from palm than from dorsum of the hand.

II) Facilitation of the motor evoked potential. Brum et al. 2016 have shown the relevance of measuring the motor-evoked potential duration in the evaluation of facilitation by voluntary contraction.

III) The relationship between limb temperature and cutaneous silent period. Kofler et al., 2014 have shown that the inhibitory reflexes of the upper limb are influenced by limb temperature.

IV) The effect of startle on internally generated movements. Castellote et al. 2013 showed that a startle accelerates the execution of movements even if they are internally generated.

V) Preparation for landing after self-programmed fall. Castellote et al. 2012 showed that landing is a pre-programmed action that is already prepared at the time of initiation of the expected fall.

VI) New technique for the study of sensory perception. Medici et al. 2013 developed the technique of dynamic thermotest and published normative values in healthy population and data in patients with small fibre polyneuropathy.

2) Characterization of the disorders that present with spasticity

I) The H wave in patients with spinal cord injury. Kumru et al. 2015 showed that the amplitude of the soleus H wave reflects the severity of the spinal cord lesion.

II) Sudomotor skin response in spinal cord lesions. Kumru et al. 2014 showed that the autonomic function reappears caudally to the level of spinal cord lesion, indicating plastic changes in the spinal cord.

III) Blink reflex in multiple sclerosis. Cabib et al. 2014 developed a method of analysing blink reflex responses for the evaluation of the effects of supranuclear lesions.

IV) Reaction time in multiple sclerosis. Cabib et al. 2015 showed that the programming of a ballistic task is defective in patients with multiple sclerosis with no evidence of clinical alterations.

3) Contributions to the treatment and improvement of function in patients with spinal cord lesion or brain injury

I) The use of vibration in spinal cord injury. Murillo et al. 2014 made a review of the topic to help rehabilitation specialists in their work.

II) The effects of repetitive transcranial magnetic stimulation on gait disorders in chronic spinal cord injury patients. Kumru et al. 2013 showed the improvement of gait with repetitive transcranial magnetic stimulation before training with robotic devices

III) Effects of non-invasive brain stimulation on spasticity in neurological diseases. Gunduz et al. 2014 used clinical scales to show improvement of spasticity with repetitive transcranial magnetic stimulation in spinal cord injury patients.

IV) Clinical guides for repetitive transcranial magnetic stimulation. Lefaucheur et al. 2014 prepared an exhaustive review of the beneficial effects of non-invasive brain stimulation in patients with neurological disorders.

4) Collateral findings

I) Thermal and mechanical hyperalgesia in patients with sequels of poliomyelitis. Kumru et al. 2013 showed that patients with muscular atrophy due to poliomyelitis experience hyperalgesia in the most affected limbs.

II) Restless legs syndrome in patients with sequels of poliomyelitis. Kumru et al. 2014 showed that the restless legs syndrome has larger prevalence in patients with sequels of poliomyelitis than in the general population.

III) Restless legs syndrome in patients with spinal cord injury. Kumru et al. 2015 showed that patients with spinal cord injury have higher prevalence of restless legs syndrome than general population. Recognition of this entity is likely to avoid unnecessary expenses of the Health System
IV) Evoked potentials and quantitative sensory testing for characterization of neuropathic pain in patients with spinal cord injury. Kumru et al. 2013 demonstrated that patients with spinal cord injury show sensitization to thermal stimulation at supralesional levels.

3. Practical implications of the results obtained after the action

The most relevant aspect of the research carried out is the increase in knowledge of functions of the nervous system in the whole human body, including motor behaviour and sensory processing. Our findings do not follow a straight line, as it was not possible to accomplish one of the objectives. On the other hand, we have managed to gather a variety of small innovations and findings that link together in the overall objective of better understanding the motor and sensory functions of the human nervous system. What makes our research homogenous is the practical clinical implications of our findings for the increase in the knowledge of pathophysiological mechanisms of neurological diseases. Some findings will have more practical implications than others but this cannot be known at present and must wait until other researchers use our observations in their research projects.

4. Publications

1: Serranová T, Jech R, Martí MJ, Modreanu R, Valldeoriola F, Sieger T, Růžička E, Valls-Solé J. A loud auditory stimulus overcomes voluntary movement limitation in cervical dystonia. PLoS One. 2012;7(10):e46586.

2: Castellote JM, Queralt A, Valls-Solé J. Preparedness for landing after a self-initiated fall. J Neurophysiol. 2012 Nov;108(9):2501-8.

3: Kumru H, Soler D, Vidal J, Navarro X, Tormos JM, Pascual-Leone A, Valls-Sole J. The effects of transcranial direct current stimulation with visual illusion in neuropathic pain due to spinal cord injury: An evoked potentials and quantitative thermal testing study. Eur J Pain. 2013 Jan;17(1):55-66.

4. Castellote JM, Van den Berg ME, Valls-Solé J. The StartReact effect on self-initiated movements. Biomed Res Int. 2013;2013:471792. doi: 10.1155/2013/471792.

5. Medici C, Barraza G, Castillo CD, Morales M, Schestatsky P, Casanova-Mollà J, Valls-Sole J. Disturbed sensory perception of changes in thermoalgesic stimuli in patients with small fiber neuropathies. Pain. 2013 Oct;154(10):2100-7.

6. Kumru H, Benito J, Murillo N, Valls-Sole J, Valles M, López-Blázquez R, Costa U, Tormos JM, Pascual-Leone A, Vidal J. Effects of high-frequency repetitive transcranial magnetic stimulation on motor and gait improvement in incomplete spinal cord injury patients. Neurorehabilitation Neural Repair. 2013;27:421-429

7. Kumru H, Portell E, Martí M, Albu S, Tormos JM, Vidal J, Valls-Sole J. Mechanical and thermal hyperalgesia in patients with poliomyelitis. Clin Neurophysiol. 2013;124:1431-1438.

8. Kofler M, Valls-Solé J, Vasko P, Boček V, Stetkárová I. Influence of limb temperature on cutaneous silent periods. Clin Neurophysiol. 2014 Feb 4. pii: S1388-2457(14)00054-6. doi: 10.1016/j.clinph.2014.01.018.

9. Westgeest A, Morales M, Cabib C, Valls-Sole J. The effects of transcranial direct current stimulation on conscious perception of sensory inputs from hand palm and dorsum. Eur J Neurosci. 2014;40:3818-3827.

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Filipović SR, Hummel FC, Jääskeläinen SK, Kimiskidis VK, Koch G, Langguth B, Nyffeler T, Oliviero A, Padberg F, Poulet E, Rossi S, Rossini PM, Rothwell JC, Schönfeldt-Lecuona C, Siebner HR, Slotema CW, Stagg CJ, Valls-Sole J, Ziemann U, Paulus W, Garcia-Larrea L. Evidence-based guidelines on the therapeutic use of repetitive transcranial magnetic stimulation (rTMS). Clin Neurophysiol. 2014;125:2150-206.

12. Murillo N, Valls-Sole J, Vidal J, Opisso E, Medina J, Kumru H. Focal vibration in neurorehabilitation. Eur J Phys Rehabil Med. 2014;50:231-242.

13. Kumru H, Schubert M, Benito J, Opisso E, Vidal J. Reappearance of sympathetic skin response below a thoracic level-9 complete spinal cord injury. Auton Neurosci. 2014;181:90-93.

14. Kumru H, Portell E, Barrio M, Santamaria J. Restless legs syndrome in patients with sequelae of poliomyelitis. Parkinsonism Relat Disord. 2014;20:1056-1058.

15. Gunduz A, Kumru H, Pascual-Leone A. Outcomes in spasticity after repetitive transcranial magnetic and transcranial direct current stimulations. Neural Regen Res. 2014;9:712-718.

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20. Kumru H, Murillo N, Benito-Penalva J, Tormos JM, Vidal J. Transcranial direct current stimulation is not effective in the motor strength and gait recovery following motor incomplete spinal cord injury during Lokomat(®) gait training. Neurosci Lett. 2016;620:143-147.