Spinal injuries: A new technology of electrostimulation for a more effective approach

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Credit: SISSA

Delivering a diversified electric message to the different fibres of the injured spinal cord through a new technology able to deliver it in a targeted and independent manner—what is the result? Greater efficiency in recovering the control of voluntary limb movements in the event of serious damage to the spinal cord. This is the focus of the research study just published in *Brain Stimulation*. By adopting a completely new approach, the study offers a significant contribution to the field of electrical stimulation for the recovery of motor function, an area of great interest for possible future clinical applications. Although the steps forward in this field have already been outstanding, with some first clinical tests conducted, much still needs to be done.

The solution developed by the international team led by Giuliano Taccola of SISSA with the collaboration of the University of California, Los Angeles and the University of Leeds, contains significant elements of innovation, which could increase the efficiency of neurorehabilitation, extending the possibilities of treatment to a higher number of individuals. Among the innovations introduced by the study, a special mention should be reserved for the more specific and effective impulse, the potential translational perspectives both in the treatment and in the diagnostics of spinal injuries, and finally the possibility to apply the technique not only in chronic situations, but also in acute ones. The promising results obtained in the research funded by the European Horizon 2020 Project "EPI nanoSTIM" have the potential to soon support a clinical trial.

Electric stimulation to restore lost functionality

"Electric stimulation of the cord to allow persons with a spinal injury to restore limb functionality is a technique that has been receiving increasing attention in these past years, thanks to some great advancements" explains Giuliano Taccola, lead author of the research. How do these systems work? "This has not been fully clarified. However, we know that in case of a spinal cord injury, when the brain sends a signal of movement, the physiological stimulus is lost at the level of injury. With our approach, the stimulating device positioned on the injured cord makes the injured spinal cord more responsive even to weak incoming messages from the brain. This way, a sort of reinforcement is created for the transmission of signals that can thus continue beyond the site of damage to reach the extremities."

The stimulus protocols however have been the same for 30 years: "Identifying more effective ones has been a major goal of this research." The scientist continues: "My participation in the study was supported by a three-year fellowship within the European Marie Sklodowska Curie

Actions, and exploited an international collaboration that involved the teams of professors Wentai Liu and Reggie Edgerton at UCLA and Ronaldo Ichiyama at the University of Leeds." They provided the unique and basic technological and instrumental support. "The foundations of this study, however, were laid with my initial in vitro research conducted at the Applied Neurophysiology Lab of SISSA, which was opened 10 years ago in Udine in collaboration with the local Institute of Physical Medicine and Rehabilitation. It is therefore a successful advancement that confirms the pivotal role of Basic Research in suggesting ideas and solutions for the future."

A new multi-electrode to stimulate the cord in different points

"At the basis of this approach," explains Taccola, "there is a multi-electrode interface originally developed by the bioengineers at the University of California, which is applied on the spinal cord. When we activate the motor cortex of the brain with a weak external stimulus, the stimulating interface turns on, showing a highly innovative functioning, that amplifies the signal from the brain, which is now able to activate lower limb muscles. My contribution in perfecting this technology was to simultaneously use each electrode of the device to deliver variable targeted stimuli to the different regions of the spinal cord." But there is more, explains Taccola "because, apart from providing a stimulus, in my experiments we proved that the electrodes of this interface can also effectively record the activity of spinal neurons. This could prove extremely useful in diagnostics, to assess the residual activity of the cord after injury."

Not all stimuli are the same

In addition to the technology, the new research leads to another innovation: "The stimuli currently used are stereotyped, namely all the same, as there is no variability in the impulse, which, on the other hand, is exactly what we changed with our work. Our stimulus varies at any point in both amplitude and frequency, continuously bringing different impulses to each area of the cord. What we found is that variable impulses work better because, as for our hypothesis, by stimulating a large area of the cord, we can provide each fibre exactly with the message it needs."

Giuliano Taccola continues, "our approach has proven effective not only in chronic situations, but also in acute ones, and this is also a novelty. In addition, the spot where the device is placed was carefully studied and assessed. In particular, our interface crosses the lesion site, to join the portion of the spinal cord above the injury with that below. This precise localisation of the device might support repair mechanisms within damaged nerve fibres."

Considering the many promising outcomes of the study, the next step the scientists will focus on will be to translate these results from preclinical research, essential for defining the technique, to people with a spinal injury.

More information: Giuliano Taccola et al, Using EMG to deliver lumbar dynamic electrical stimulation to facilitate cortico-spinal excitability, *Brain Stimulation* (2019). DOI: 10.1016/j.brs.2019.09.013

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