Effects of Epidural Spinal Stimulation on Cortical Activity and Motor Output During Power Grip in Cervical Spinal Cord Injury

Milton Candela[1], JeongHoon Oh[1], Dimitry Sayenko[1,*] and Alexander Steele[1]

1. Department of Neurosurgery, Center for Neural Systems Restoration, Houston Methodist Hospital, Houston, TX, USA

Corresponding author: Dimitry Sayenko, Department of Neurosurgery, Houston Methodist, 6550 Fannin Street, Houston, TX 77030, USA. E-mail:dgsayenko@houstonmethodist.org

Spinal Cord Injury (SCI) can disrupt the corticospinal tract, impairing motor control below the level of injury. In complete cervical SCI (AIS A), no clinically detectable sensory or voluntary motor functions are present below the level of injury, rendering individuals unable to produce functional upper-limb muscle activity or force. Epidural Spinal Stimulation (ESS) can facilitate volitional muscle activation and enhanced force generation after an SCI. However, the supraspinal effects of sub-lesional ESS during volitional motor tasks are not fully understood. To address this, we investigated changes in cortical activity and motor output during a power grip task in two participants with chronic cervical SCI (AIS A). We recorded high-density 64-channel Electroencephalography (EEG) with source localization (sLORETA), upper-limb Electromyography (EMG) with Root Mean Square (RMS) from eight upper-limb muscles, including arm (BIC, TRIC), forearm (FCR, FCU, ECR, ECU), and hand (APB, LDI), and grip force during 12 trials with and without ESS. Without stimulation, participants produced minimal force (<1 N) and EMG activity (RMS <5μV). With stimulation, SCI02 exhibited a two-fold increase in grip force, EMG activity, and primary motor cortex (M1) activation compared to without stimulation. In contrast, SCI01 had no significant differences at M1 activity, force, and EMG activity between the no stimulation and stimulation conditions. These preliminary findings suggest that, in individuals with chronic cervical SCI, sub-lesional ESS can facilitate motor output associated with cortical activation, consistent with enhanced engagement of residual descending and ascending pathways, even in clinically complete injury. Given the limited sample size, further studies with larger cohorts, alternative neuroimaging techniques, and varied motor tasks are needed to confirm these findings.