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Neuromodulation in multi-functional rehabilitation for patients with spinal cord injury

Abstract:
Spinal cord injury (SCI) is a devastating condition associated with widespread functional impairments, including profound disruptions of motor, respiratory, and cardiovascular systems, dysfunctions that are major contributors to long-term morbidity and mortality. While activity-based rehabilitation has demonstrated potential for promoting neural recovery, its efficacy is often constrained by the limited excitability of spinal networks below the lesion. Recent advances in neuromodulatory interventions, both invasive (epidural spinal cord stimulation) and non-invasive (transcutaneous spinal cord stimulation), have shown promise in enhancing spinal network excitability and facilitating neuroplasticity when combined with task-specific training. In this presentation, I will outline the pathophysiological basis of motor and autonomic deficits after SCI and review the methodology and rationale behind integrating neuromodulation into multi-functional rehabilitation strategies. Drawing from our clinical research program, I will present evidence supporting the efficacy of targeted spinal stimulation paradigms for restoring voluntary movement, stabilizing blood pressure, and improving respiratory motor control. These findings suggest that spinal neuromodulation, particularly when combined with activity-based interventions, may overcome intrinsic limitations of traditional therapies by enabling functionally meaningful recovery. The incorporation of these multi-modal strategies into clinical practice could represent a transformative shift in the rehabilitation of individuals with SCI and other neurological disorders.

Keywords: Spinal cord injury, Neuromodulation, Activity-based rehabilitation, Spinal cord stimulation, Neuroplasticity

Biography: Professor Alexander Ovechkin received his MD and PhD from Perm State Medical Academy. In 1999, he joined the University of Louisville, where he earned a second PhD in Physiology while investigating pulmonary-cardiovascular regulation. Since 2006, he has served on the faculty of the Department of Neurological Surgery and the Kentucky Spinal Cord Injury Research Center, where he established the Laboratory of Clinical Respiratory-Cardiovascular Neurophysiology. His research focuses on neurophysiological evaluation and rehabilitation of locomotor, respiratory, and cardiovascular deficits in spinal cord injury using activity-based therapies combined with invasive and non-invasive spinal neuromodulation. He leads multiple NIH-funded clinical trials.

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