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Predicting Return to Consciousness in Patients with TBI: Why the Thalamus May Be Key

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Recent studies suggest thalamic input correlates to restoration of conscious, goal-directed behavior

A new model for the recovery of consciousness in patients with traumatic brain injury (TBI) is emerging from newly published research. The model implies that thalamic input plays a vital role in the restoration of complex prefrontal cortex activity associated with human consciousness. This may help predict the likelihood of return to consciousness in patients with TBI and inform the development of future neuro-modulatory treatments to facilitate the process.

Chuck Mikell, MD, Co-Director of the Stony Brook Movement Disorders Center and Co-Director of the Stony Brook Neuro-Oncology Center at Stony Brook Medicine in New York and Sima Mofakham, PhD, a computational/ system neuroscientist and Director of Research — both Assistant Professors in the Department of Neurosurgery at the Renaissance School of Medicine at Stony Brook University — are among a team of researchers that authored four papers which collectively establish a correlation between the integrity of thalamocortical connections and recovery of consciousness following TBI.[1-3]

Their most recent paper presents results from a retrospective study of 15 TBI patients, testing the hypothesis that thalamic input facilitates complex electroencephalographic (EEG) activity in the corticothalamic system.[3] Complex EEG activity has a well-established connection with return to consciousness and goal-directed behavior in humans, though the causes of such activity remain unclear.

Researchers found a direct relationship between EEG signal complexity and the integrity of a patient's thalamo-prefrontal circuit. They likewise found a correlation between clinical outcomes and high-frequency prefrontal cortex activity as measured by EEG. Patients with favorable clinical outcomes had EEGs showing prominent alpha and beta oscillations while those with unfavorable clinical outcomes had EEGs dominated by delta oscillations. Patients were considered to have favorable clinical outcomes if they returned to consciousness (defined as a patient's ability to respond to simple verbal commands) within 2 months of their TBI and had a Glasgow Outcome Score (GOS) >2 at discharge.

Importantly, the researchers also discovered that injury to thalamo-prefrontal circuits resulted in 'attractor dynamics' and predictable brain signals. As Dr. Mofakham explains, "Attractors are ways of describing a repetitive activity which the brain has trouble escaping, like a whirlpool or a black hole. For cortical networks, attractors limit the repertoire of the available brain states, and consequently behavior."

Sima Mofakham, PhD

Chuck Mikell, MD

This helps explain the predictable behavior patterns of TBI patients who have unfavorable clinical outcomes. "After brain injury, comatose, unconscious, and semi-conscious patients don't do very much," said Dr. Mikell. "They might roll around the bed, or have purposeless movements, but they don't engage in goal-directed behavior. Their behaviors are highly predictable."

These findings stand as a culmination of earlier research the team reported in previous papers. In one first-of-its-kind study, the researchers implanted electrodes deep in the brains of 5 comatose patients with TBI. In these patients, they discovered that the thalamus facilitated cortical ensemble formation, a requirement for return to consciousness.[1] A second study in 25 patients who had suffered severe TBI demonstrated that those with thalamic injury were less likely to recover the content of their consciousness.[2] In another paper, the team reported a limited number of cortical states and predictable brain dynamics in patients with injuries to the thalamus and its projection to the cortex.[3]

Through these efforts, Dr. Mofakham and Dr. Mikell have identified the brain circuits responsible for unpredictable brain activity and behavior, which they believe to be hallmarks of human consciousness.

Research into TBIs, return to consciousness, and the thalamocortical loop is ongoing at The Mofakham Mikell Lab at the Renaissance School of Medicine at Stony Brook University. Dr. Mofakham, Dr. Mikell, and their team of researchers are investigating the safety and effectiveness of deep brain stimulation to restore thalamocortical connections. They are also working to develop objective clinical metrics that can help with prognosis and the assessment of patient improvement or deterioration. Their hope is that these efforts will help guide clinical decisions in unprecedented ways, while also providing the means to measure the effectiveness of prospective treatments.

Dr. Mofakham and Dr. Mikell look forward to further studies by their team and others aimed at investigating the utility of augmenting thalamic activity to help facilitate restoration of consciousness in patients with TBI.

Refer a Patient

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