High angular resolution diffusion-weighted imaging and higher order tractography of the white matter tracts in the anterior thalamic area: Insights into deep brain stimulation targeting

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Abstract

Deep brain stimulation of the anterior nucleus of the thalamus (ANT) is emerging EU/US-approved form of therapy for drug-resistant focal epilepsy. Its mechanism of action is not yet fully understood, and the patient outcomes in epilepsy appear less consistent compared to for instance movement disorders. The knowledge of the anatomical connections such as tractography of relevant fiber systems, exists guiding DBS therapy at present is very limited. We aim to demonstrate ANT-related fiber systems based on histology. MSMT-CSD based deterministic and probabilistic tractography using HARDI data acquisition protocol in healthy volunteers. Data was acquired from five healthy volunteers in a 3T Siemens MAGNETOM Skyra MRI machine using multiple b-values (1000, 2000, and 3000), 64 directions, and pre-processed for tractography. MSMT-CSD-based deterministic and probabilistic tractography was performed. Multiple fiber systems were identified: The anterior thalamic radiation (ANT), thalamo-cingulate tract, the inferior thalamic peduncle (with remote termination areas in the amygdala, the ventral tegmental area, and the occipital cortex), and the mammillothalamic tract. We observed three parallel connections to the hippocampus (via the cingulum bundle, the fornix, and the temporo-pulvinar pathway). Interestingly, different seed areas in ANT complex mimicking DBS contact locations resulted in visualization of different fiber systems. The connections of ANT are complex. Different stimulation sites affect different networks depending on lead locations and the selection of the active contact. Understanding of the connections of ANT is likely to influence therapy outcomes. A hypothetical model of neuronal networks affected by different DBS lead contact locations is proposed.