Development of New Treatments for Traumatic Brain Injury, Diffusion MRI at 21T

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Introduction

Every year 1.5 million Americans sustain a traumatic brain injury (TBI). Of these, about 50,000 die and 235,000 are hospitalized. One of the main dangers of TBI is edema, (water accumulation at the site of injury) and swelling. These effects damage brain tissue immediately after injury, and, particularly, the size of cytotoxic edema is associated with a poor long-term clinical prognosis. The development of new treatments to improve outcomes after TBI is limited by our incomplete understanding of the mechanisms responsible for the development of edema after injury and by lack of knowledge pertaining to the acute heterogeneity and severity of individual brain damage.

Experimental

A weight-drop model of TBI in the adult rat was developed that produces an identifiable necrotic cavity which is associated with significant behavioral impairments. This model was used to investigate how the administration of hormones at 1 and 6 hours post-injury can reduce effects of injury at 24 hours post-TBI exam. Recently, in vivo diffusion mapping was developed at NHMFL and was tested for use with large rodents at ultra high magnetic field of 21T. Development of the diffusion pulse sequence included several special measures to prevent natural motions as breathing and blood flow from distorting the results of MR diffusion map imaging.

Results

Two therapies were tested: thyrotropin releasing hormone (TRH) or progesterone in combination with the active hormone dihydroxy-vitamin D. Cytotoxic edema, observed as dark areas, decreased as a result of both therapies (Fig. 1).

![Fig. 1. Two types of edema were detected by diffusion mapping MRI at 21T and seen as light and dark areas inside rat brain.](image)

Conclusions

This work demonstrates the latest achievement of in vivo MRI at 21T. The results, first of all, reveal the power of diffusion weighted imaging at high magnetic fields to separate two types of edema, and separately detect cytotoxic edema which needs very urgent therapy after TBI. It also shows the dramatic effects of new combinatorial treatments for improving the outcomes after TBI. The new imaging capabilities at the NHMFL are very valuable for the future testing and development of novel therapies for traumatic brain injury.

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