Carnegie Mellon MRI technology that non-invasively locates, quantifies specific cells in the body

August 21 2008

Magnetic resonance imaging (MRI) isn't just for capturing detailed images of the body's anatomy. Thanks to novel imaging reagents and technology developed by Carnegie Mellon University scientist Eric Ahrens, MRI can be used to visualize — with "exquisite" specificity — cell populations of interest in the living body. The ability to non-invasively locate and track cells, such as immune cells, will greatly aid the study and treatment of cancer, inflammation, and autoimmune diseases, as well as provide a tool for advancing clinical translation of the emerging field of cellular regenerative medicine, by tracking stem cells for example.

Ahrens will present his research on this new approach, called fluorocarbon labeling, Thursday, Aug. 21 at the 236th national meeting of the American Chemical Society in Philadelphia.

"With our technology we can image specific cells in real-time with exquisite selectivity, which allows us to track their location and movement and to count the apparent number of cells present. We then use conventional MRI to obtain a high-resolution image that places the labeled cells in their anatomical context," said Ahrens, an associate professor of biological sciences at the Mellon College of Science.

The ability to track the movement and eventual location of specific immune cells is critical for understanding the cells' role in disease and

therapeutic mechanisms, and for developing effective cell-based therapeutics. Other MRI methods for visualizing cells use metal-based contrast agents, which can make it difficult to clearly identify labeled cells in the body, according to Ahrens.

"The large background signal from mobile water and intrinsic tissue contrast differences can often make it challenging to unambiguously identify regions containing these metal-ion labeled cells throughout the body, which is the current state of the art," Ahrens said.

Ahrens's new approach — fluorocarbon labeling — solves this problem by producing images that clearly show the labeled cells at their precise location in the body. Ahrens first labels the cells of interest with a perfluoropolyether (PFPE) nanoemulsion, which is a colloidal suspension of tiny fluorocarbon droplets. Then, he introduces the labeled cells into an animal subject and tracks the cells in vivo using 19F MRI.

While conventional MRI detects the nuclear magnetic resonance signal from protons contained in the mobile water in tissue, 19F MRI detects the signal from the nucleus of the fluorine atom. Fluorine is not normally present in the body at sufficient concentrations to detect, so when Ahrens labels cells with PFPE, he can detect this fluorine 'tracer' with MRI after the cells are transplanted into the body. The Ahrens' team has recently used the PFPE technology to label and track dendritic cells and T cells in a mouse model of type I diabetes, a disease in which immune cells infiltrate the pancreas, attacking and damaging the body's own cells.

"Right now we're using our technology to image key cell types involved in autoimmune diseases like type I diabetes, but our cellular MRI agents also can be adapted to label other cell types, including cells from bone marrow and stem cells. A key long-term application of our technology is to label and monitor cell-based therapeutics in humans," Ahrens said.

Recent advances in cell-based therapeutics research have focused on training immune cells to counteract diseases including cancer and diabetes and on directing stem cells to regenerate damaged tissues. Non-invasively visualizing these therapeutic cells in patients after transfer can be a vexing problem, according to Ahrens, and any approach that can speed up the testing of these treatments will be extremely useful.

"Ideally we would label therapeutic cells with our cellular MRI agents before they are implanted into a patient. In this way, we could use MRI to visualize the movement of the therapeutic cells in the patient to monitor whether they migrate to and remain in the desired tissues," explained Ahrens.

Source: Carnegie Mellon University