magnetic INSIGHT

High-Sensitivity Inflammation Detection in Small Animal Models with Magnetic Particle Imaging

1. Zheng et al. 2016

Inflammation Imaging

Inflammation is a part of the body's response to harmful stimuli, such as damaged cells, irritants, and pathogens. It is characterized by vasodilation, accumulation of fluid, and the extravasation of immune cells (primarily leukocytes). As such, the detection and monitoring of localized inflammation is an important indicator of disease.

Magnetic Particle Imaging (MPI) is an emerging molecular imaging modality that directly detects iron-oxide nanoparticle tracers within the body. Because the tracer is not normally found in the body, MPI images have exceptional contrast and high sensitivity. This allows us to visualize tracers in cells (immune cell tracking), blood (perfusion), and other functional systems (antigen targeting and drug delivery systems) within a living organism.

Immune cells can be tagged with magnetic nanoparticles, allowing those specific cells to be tracked as they migrate and accumulate within regions of localized inflammation.[2]

The nanoparticles can also be directly injected, where they are captured by phagocytotic immune cells. Inflammatory burden can be measured when these cells home to sites of inflammation. Using magnetic particle imaging, regions of inflammation can be quantitatively monitored over time for days to weeks.

Researchers can use MPI to assess whole body inflammation in a variety of pre-clinical models:

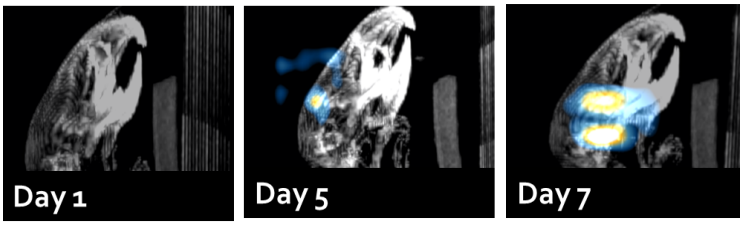
- —Traumatic brain injury[3]
- —Stroke and perfusion[4]
- —Cancer and tumor-associated macrophages[5]
- —Infectious disease
- —Autoimmune disease (MS, arthritis)

CELL THERAPY | NEUROIMAGING | INFLAMMATION | LOCALIZED HYPERTHERMIA | NANOPARTICLE DEVELOPMENT

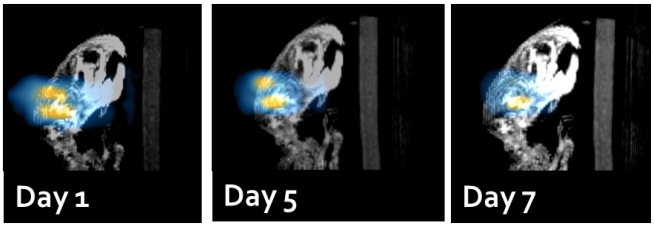
Chemically Induced Neuroinflammation (NIF)

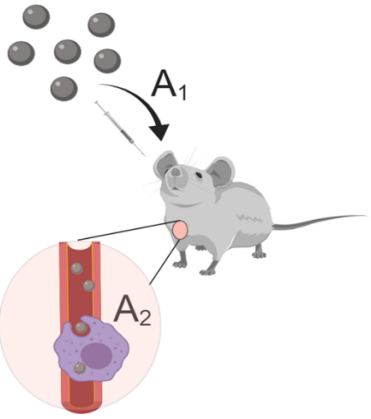
Lipopolysaccharide (LPS), an endotoxin from the outer membrane of bacteria, is known as a potent trigger of inflammation. Following intracranial LPS administration, MPI was used to quantify monocyte homing and spatial distribution in the neuroinflammation region. Infiltration of immune cells was monitored by two methods: 1) through *in situ* uptake of particles by native phagocytic cells or 2) by allogenic monocytes tagged *ex vivo*.

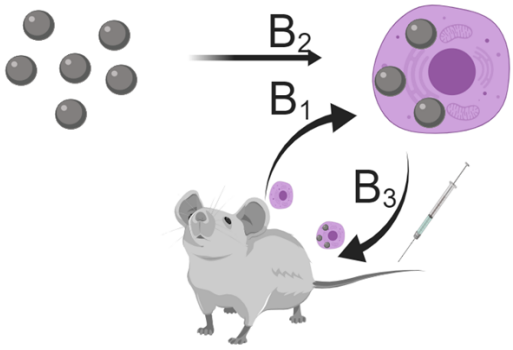
in situ Labelling



ex vivo Labelling







A1: Nanoparticles administered IV
A2: Phagocytic cells take up nanoparticles *in situ*

Examples:
—Tumor-associated macrophages[3]
—Traumatic brain injury[2]
—Stroke[4]
—Rheumatology
—Surgery-induced tissue damage

B1: Collect cells
B2: Incubate and label *in vitro*
B3: Inject *in vivo*

Examples:
—Macrophages / Monocytes
—Dendritic cells
—Neutrophils
—T-cells
—Non-immune cells (stem cells, tumor cells, islet cells, cardiomyocytes, etc.)

References

1. Zheng, Bo, et al. "Quantitative magnetic particle imaging monitors the transplantation, biodistribution, and clearance of stem cells in vivo." Theranostics 6.3 (2016): 291.

2. Zhou, Xinyi Y., et al. "Magnetic particle imaging for radiation-free, sensitive and high-contrast vascular imaging and cell tracking." Current opinion in chemical biology 45 (2018): 131-138.

3. Orendorff, Ryan, et al. "First in vivo traumatic brain injury imaging via magnetic particle imaging." Physics in Medicine & Biology 62.9 (2017): 3501.

4. Makela, Ashley V., et al. "Magnetic Particle Imaging of Macrophages Associated with Cancer: Filling the Voids Left by Iron-Based Magnetic Resonance Imaging." Molecular Imaging and Biology (2020): 1-11.

5. Wu, L. C., et al. "A review of magnetic particle imaging and perspectives on neuroimaging." American Journal of Neuroradiology 40.2 (2019): 206-212.