National Institutes of Health

Fact Sheet — ***Neurological Imaging***

Yesterday

- Neurologists and neurosurgeons made clinical decisions based on first generation computed tomography (CT) scans. This was a quantum advance over the insensitive plain film X-ray techniques of previous generations.
- Early positron emission tomography (PET) and single photon emission computed tomography (SPECT) techniques utilized first generation radiographic tracers (or tags) to map brain function.

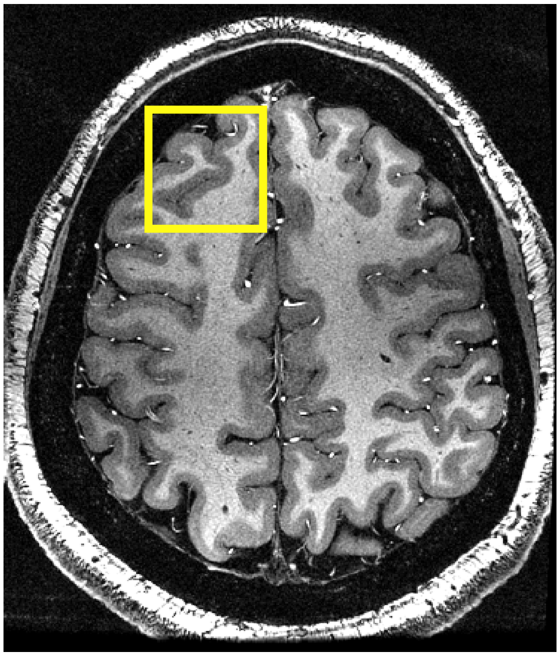
Today

- Advanced magnetic resonance imaging (MRI) including functional MRI, as well as advances in CT, SPECT and PET are revolutionizing the care of patients with neurologic disorders.
- The resolution of brain and spinal cord imaging has increased tremendously. For example, modern techniques allow the neuroimaging of subtle abnormalities of neurological development that give rise to seizures and enable many more persons to benefit from a surgical treatment of epilepsy. MRI can now identify spinal vascular malformations that are amenable to treatment before they cause paralysis. Many of these went undiagnosed 30 years ago.
- Blood oxygen level dependent (BOLD) MRI imaging can now map brain activity in humans enabling the non-invasive study of everything from finger movements to thoughts and emotions. BOLD imaging of the location of important brain functions also guides the operative strategy in neurosurgery.
- Diffusion-weighted MRI imaging (DWI) is a breakthrough that enables the identification of early-stage injury in stroke patients. Perfusion imaging is also commonly used in stroke patients to define the region at risk for tissue death due to oxygen depletion. Prior to DWI, neuroimaging could not identify the early treatable stage in stroke patients.
- CT angiography substantially decreased the need for more dangerous catheter-based angiography.
- MRI is invaluable in the diagnosis of patients with multiple sclerosis and spinal cord disorders.
- Advanced diagnostics in many neurological diseases/disorders now are increasingly used as a means to monitor the progression of disease and response to treatment. For example, the development of Pittsburgh Compound B now permits the molecular imaging of the amyloid beta protein in patients with Alzheimer's disease.
- Advanced image processing allows clinicians and researchers to measure the subtle shrinkage of brain regions over time (from chronic disease progression) and use this information to test new therapies.
- PET imaging using compounds that bind to brain receptors now allows the study of molecular details not previously visualized.
- Magnetic resonance (MR) spectroscopy allows measurement of brain chemicals in living patients.

Tomorrow

- Enhancements in image resolution and specific molecular tags will permit clinicians to diagnose a wide range of diseases accurately, based on both structural and molecular changes to the brain.
- Individual groups of cells will be identifiable and clinicians will be able to gather information on the presence and distribution of specific molecules. For example, imaging will facilitate the diagnosis of complex forms of dementia that are clinically similar but are currently not possible to diagnose definitively until autopsy.
- Improved resolution will permit clinicians and surgeons to better understand their targets and optimize their approach when treating conditions such as brain tumors, aneurysms, etc. Advancements in imaging will also enable medicine to be more personalized. For example, imaging in the emergency department is being tested as a way to determine which stroke patients will benefit from "clot-busting" treatment beyond the current three hour therapeutic window.

The following images illustrate advances in brain tissue resolution provided by increasingly powerful MRI technology. MRI utilizes radiofrequency waves and strong magnetic fields (measured in units called Tesla) to non-invasively distinguish soft-tissue structures in the body. The area of the brain outlined in yellow in this "slice" is shown in magnification, using MRI at three different strengths.



Images courtesy of Dr. Jeff H. Duyn, Advanced MRI Section,
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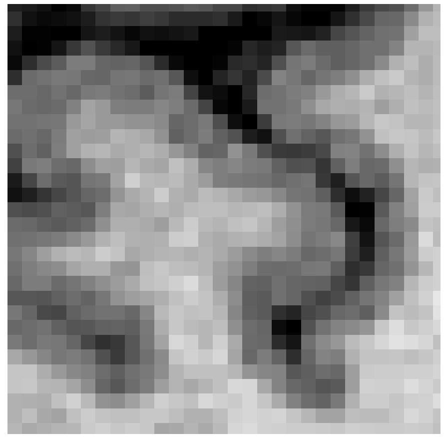
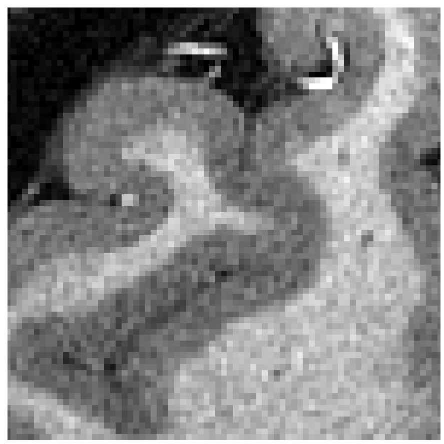
Below, images of the folds on the outside of the brain (called gyri) are illustrated with greater clarity as the power of the magnet and the data-collecting capability (e.g., the number of "channels") are increased.



2001: 3 Tesla; single channel detector
1x1x1 mm resolution



2006: 7 Tesla; 24 channel detector
0.4x0.4x1 mm resolution

2007: 7 Tesla; 32 channel detector
0.2x0.2x0.5 mm resolution