NATIONAL INSTITUTES OF HEALTH

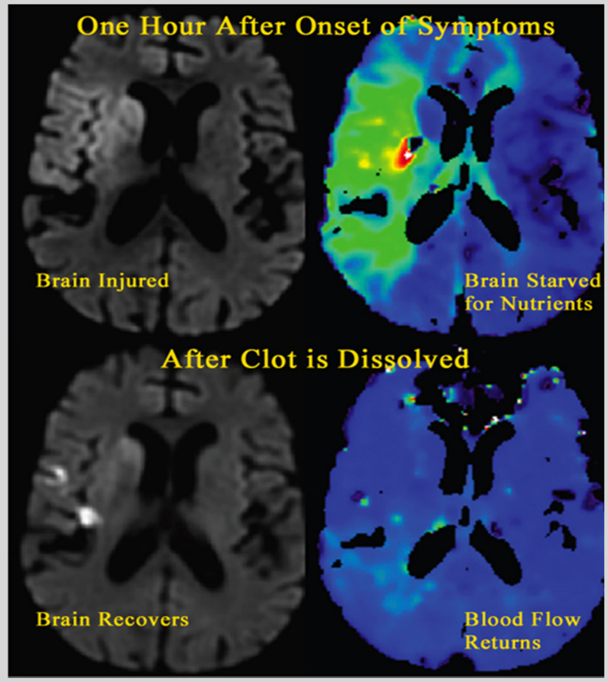
Neurological Imaging

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.
- Functional magnetic resonance imaging (fMRI) allowed researchers to measure blood oxygen level dependent (BOLD) changes in the brain of humans for the first time. fMRI enabled the non-invasive study of everything from finger movements to thoughts and emotions.

Today

- Advanced magnetic resonance imaging (MRI) is revolutionizing the care of patients with neurologic disorders, as well as research in understanding the brain. Magnetic resonance (MR) spectroscopy allows measurement of brain chemicals in living patients. PET imaging using compounds that bind to brain receptors now allows the study of molecular details not previously visualized.
- 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. Many of these went undiagnosed 30 years ago.
- Functional MRI BOLD imaging enables researchers not only to localize and measure important brain functions, but also to assess functional changes in the brain resulting from disease processes, injury, or response to treatment. fMRI is also being used to guide operative strategy in neurosurgery.



These MRI images show an ischemic stroke as it is happening and as it recovers. One hour after the onset of stroke symptoms, a region of brain is starved of blood because of clot in an artery [as seen in the colorized version of perfusion MRI] and injured cells within the region light up on the stroke MRI [as seen in the black and white diffusion weighted MRI]. After the clot is dissolved by clot-busting drugs and blood returns to nourish the deprived brain region [second perfusion MRI] much of the injured brain recovers [second DWI]. Credit: NINDS

- Diffusion tensor imaging, a technique that allows for the visualization and characterization of white matter tracts in the human brain, is allowing researchers to assess changes in the brain's maturation from childhood to adulthood, as well as to detect differences in white matter integrity between healthy and diseased populations.
- 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. In addition, MRI has become invaluable in the diagnosis of patients with multiple sclerosis and spinal cord disorders.

- 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. Furthermore, neuroimaging has made it possible to detect, characterize, and monitor objective brain changes after insults such as traumatic brain injury.

- Neuroimaging has played a crucial role in advancing understanding and treatment of stroke, and is now recommended by national guidelines for acute assessment and treatment decisions and for secondary prevention. Ongoing studies are using different forms of imaging at different time points after stroke to help hospitals better identify patients who could benefit from treatment beyond the current window.

Tomorrow

- Advanced neuroimaging techniques will allow researchers to understand all of the structural and functional pathways in the entire, living human brain. This groundbreaking advance could lead to more accurate diagnosis and treatment of a variety of neurological and mental disorders. The NIH has launched the Human Connectome Project (http://www.humanconnectomeproject.org/), a $30 million multi-site project that aims to understand genetic and environmental influences on brain connectivity, as well as how dysfunction in connectivity can contribute to neurological and mental conditions.

- Scientists will be able to use imaging to understand cognitive impairment in neurodegenerative diseases such as Alzheimer's. The ongoing Alzheimer's Disease Neuroimaging Initaitve (ADNI) (http://www.adni-info.org/), a multi-site, longitudinal, prospective study of normal cognitive aging, mild cognitive impairment (MCI), and early Alzheimer's disease (AD), will enable researchers to define rates of impairment, design improved methods for clinical trials, and develop more effective techniques to treat and prevent Alzheimer's Disease.

- In the future, scientists will be able to use neuroimaging to determine consciousness states of individuals. A series of intriguing studies has improved the clinical assessment of states such as coma, vegetative state, minimally conscious state, and locked in syndrome, providing new information about evaluation of brain function, formation of diagnoses, and estimation of prognosis.

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National Institute of Neurological Disorders and Stroke (NINDS) website: http://www.ninds.nih.gov/