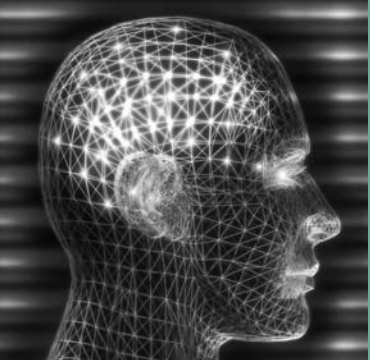

Summer 2008

front line

A PUBLICATION OF ABBOTT NORTHWESTERN HOSPITAL'S NEUROSCIENCE INSTITUTE

Techniques for Neurological Imaging

by Neeraj B. Chepuri, MD

Neurological imaging (neuroimaging) refers to the various techniques used to view the structure or function of the central nervous system, including the brain and spine. Although it is relatively new, neuroimaging has gained broad acceptance around the world for diagnosing and treating patients with neurological impairments. In fact, neuroimaging accounts for approximately half of all cross-sectional medical imaging performed in the U.S.

Neuroimaging falls into two broad categories: structural and functional. Structural imaging deals with the structure of the brain, the diagnosis of gross intracranial disease (such as a tumor) and injury. Functional imaging is used to diagnose metabolic diseases (such as Alzheimer's disease) and lesions on a finer scale. It is also used for neurological and psychological research. Functional imaging creates a direct view of centers in the brain that process certain types of information. Such processing causes the involved area of the brain to increase metabolism and "light up" on the functional scan.

Brain imaging techniques

Computed Tomography (CT) or Computed Axial Tomography (CAT) scans use a series of head X-rays taken from many different directions. Typically used for quickly viewing brain injuries, CT uses a computer program to perform a numerical integral calculation on the measured X-rays to determine how much of an X-ray beam is absorbed in a small volume of the brain. The information is presented as cross sections of the brain. The denser a material is, the whiter it will appear on the scan (just as in the more familiar "flat" X-rays). CT of the CNS has many applications, and is often used for emergency patients because it can produce images in a matter of minutes.

Magnetic Resonance Imaging (MRI) uses magnetic fields and radio waves to produce high quality two- or three-dimensional images of brain structures without using ionizing radiation or radioactive tracers. During an MRI, a large magnet creates a magnetic field around the head of the patient through which radio waves are sent. When the magnetic field is imposed, each point in space has a unique frequency at which the signal is received and transmitted. Sensors read the frequencies and a computer uses the information to construct an image. The detection mechanisms are so precise that changes in structures over time can be detected.

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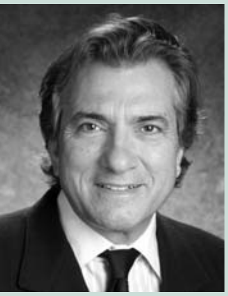
Dear Colleagues,



With the publicity around the treatment of brain tumors associated with Senator Ted Kennedy's illness, we thought we would provide you with information about some of the latest treatment options available for persons with malignant brain tumors at Abbott Northwestern Hospital.

Also featured in this edition is one of my colleagues, Sabrina Walski-Easton, MD, who joined our team of surgeons in October 2006 and expands our practice to accommodate patients with spine disease.

Our third article discusses neuroimaging. If you have not witnessed the latest MRI technology you will be very interested in Dr. Chepuri's article on Functional MRI. Dr. Chepuri will be presenting at the 21st annual Front Line Neurology Symposium being held on Oct. 2 and 3 at the Hilton Hotel in Bloomington along with Dr. Trusheim and Dr. Walski-Easton.

Please mark your calendar for this exciting conference and feel free to call 612-863-3339 for more information. You should see a brochure in the mail in early August.

Wishing you a relaxing summer,

Mahmoud Nagib, MD

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Techniques for Neurological Imaging, *continued from page 1*

MRI is frequently used to create images of CNS structures with a high degree of anatomical detail. MRI scans can produce cross-sectional images in any direction – top to bottom, side to side or front to back. In its early stages, MRI was limited to providing a detailed assessment of the physical appearance, water content and many kinds of subtle derangements of brain structure (such as inflammation or bleeding). More recently, MRI has been used to provide information about the brain's metabolism at the time of imaging. A distinction is therefore made between "MRI" and "functional MRI" (fMRI). While MRI provides only structural information about the brain, fMRI yields both structural and functional data.

Functional Magnetic Resonance Imaging (fMRI) relies on the paramagnetic properties of oxygenated and deoxygenated blood to show images of changing blood flow associated with neural activity. This generates images that reflect which brain structures are activated (and how) as the patient performs different tasks. Most fMRI scanners allow subjects to be presented with different visual, audio and touch stimuli, and to carry out actions like pressing a button or moving a joystick. As a result, fMRI can be used to show brain structures and processes associated with perception, thought and action. Presently, the resolution of fMRI is about two to three millimeters, limited by the spatial spread of the hemodynamic response to neural activity.

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In addition to research on healthy subjects, use of the fMRI has expanded to include the diagnosis of disease. Because fMRI is extremely sensitive to blood flow, it can accurately detect early changes in the brain resulting from a brain tumor or ischemia. One major recent advance in functional imaging is the use of fMRI to characterize the brain tissue adjacent to brain tumors. This allows neurosurgeons to more effectively plan the removal of tumors before opening the skull.

Positron Emission Tomography (PET) measures emissions from radioactively labeled, metabolically active chemicals that have been injected into the bloodstream. The emission data are computer-processed to produce two- or three-dimensional images of the distribution of the chemicals in the brain. The positron-emitting radioisotopes used are produced by a cyclotron, and chemicals are labeled with these radioactive atoms. The labeled compound, called a radiotracer, is injected into the bloodstream and eventually makes its way to the brain. Sensors in the PET scanner detect the radioactivity as the compound accumulates in various regions of the brain. A computer uses the data gathered by the sensors to create multi-colored two- or three-dimensional images that show where the compound acts in the brain. The wide array of ligands are especially useful in mapping different aspects of neurotransmitter activity. A labeled form of glucose is the most commonly used PET tracer.

The greatest benefit of PET scanning is that different compounds can show blood flow, oxygen and glucose metabolism in the tissues of the working brain. When they were first introduced, PET scans were superior to all other metabolic imaging methods in terms of resolution and speed. The improved resolution permitted better study of the area of the brain activated by a particular task. The biggest drawback of PET scanning is that the radioactivity decays rapidly, so its use is limited to monitoring short tasks. Before fMRI technology came along, PET scanning was the preferred method of functional brain imaging. It still continues to make large contributions to neuroscience.

> **Positron Emission Tomography (PET) measures emissions from radioactively labeled, metabolically active chemicals that have been injected into the bloodstream.**

PET scanning is also used for diagnosing brain disease. Brain tumors, strokes and neuron-damaging diseases produce great changes in brain metabolism. These changes are easily detected in PET scans. PET is probably most useful in early cases of certain dementias (e.g., Azheimer's disease and Pick's disease) because it shows the early damage that CT and standard MRI images may not show. Early damage is often too diffuse and the difference in brain volume and gross structure wouldn't change CT or standard MRI images enough to reliably differentiate it from the "normal" range of cortical atrophy which can occur in aging persons, and which does not cause clinical dementia. ■

Neeraj B. Chepuri, MD, graduated from the University of Minnesota Medical School, Minneapolis, in 1996 and completed a residency in diagnostic radiology at the University of Michigan Hospitals and Clinics, Ann Arbor, Mich. He then completed the Diagnostic Neuroradiology Fellowship Program at Bowman-Gray School of Medicine, Winston-Salem, N.C. He is a senior member of the American Society of Neuroradiology and a clinical assistant professor in the Department of Neurology at the University of Minnsota. He has been in practice with the Neuroradiology Section of Consulting Radiologists, Ltd. since 2002. ■

O-arm and Stealth Navigation Facilitate Minimally Invasive Spinal Surgery and Intraoperative Brain Imaging

by Sabrina M. Walski-Easton, MD

Abbott Northwestern continues to improve patient care with new technology. The Breakaway Imaging O-arm™ CT fluoroscopy machine made its debut in December 2007. This revolutionary technology allows surgeons to obtain CT scans for brain or spinal surgery in the operating room without transporting the patient to radiology, making minimally invasive surgeries safer and easier.

Like iMRI, which demonstrates the movement or shift of brain tissue that occurs during surgery and can confirm that surgical goals were accomplished, the intra-operative O-arm provides real-time images during surgery. The CT scans provided by the O-arm are best used for defining bony anatomy and are particularly useful in spinal applications.

When combined with Stealth Navigation, O-arm improves surgical accuracy and facilitates less invasive spinal surgery. Stealth Navigation is

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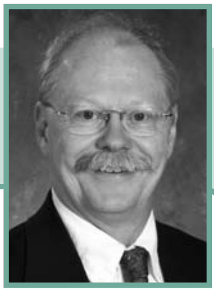
Spinal problems are extremely common and are the second most common reason people seek medical attention. They account for 15 percent of all medical leaves and are the most common cause for disability for persons under the age of 45.

Abbott Northwestern's Brain Tumor Center Offers State-of-the-Art Therapies

by John Trusheim, MD



John Trusheim, MD, received his medical degree from the University of Missouri, Columbia, Mo. He completed internal medicine and neurology residencies and a fellowship in neuro-oncology at the University of Minnesota, Minneapolis. Trusheim is medical director of neuro-oncology at the Virginia Piper Cancer Institute. He has practiced with the Minneapolis Clinic of Neurology since 1987. ■

In oncology research, the management of malignant brain tumors poses a tremendous challenge. True to its commitment to caring for patients with malignant brain tumors, Abbott Northwestern has begun using a world class intra-operative MRI (iMRI) suite and state-of-the-art radiation therapy equipment. Most patients of this type require multimodality intervention with surgical removal of their tumors, followed by radiation therapy and chemotherapy. Abbott Northwestern's Brain Tumor Center is one of the few centers nationwide to offer two of the most advanced therapies for these difficult tumors.

Blood Brain Barrier Disruption Therapy

The blood brain barrier is a unique vascular structure of the nervous system which prevents large molecules from entering the Central Nervous System (CNS). This barrier also prevents the delivery of potentially helpful chemotherapy compounds from reaching their target in patients with CNS tumors.

Fortunately, much research is being devoted to this blood brain barrier and the corresponding "blood-tumor-barrier." One technique involves the active opening of the barrier during an angiographic procedure done to deliver chemotherapy. At Abbott Northwestern, this option will now be included in its intra-arterially delivered chemotherapy program. This program is made possible by the expertise of interventional radiologists and anesthesiologists.

Patient-specific Tumor Vaccine Therapy

A second, potentially groundbreaking tumor therapy is immunotherapy with the specific goal of using a patient's own tumor cells and immune system to treat primary brain tumors. Patients who are enrolled in this trial will receive maximal neurosurgical resections of their tumors along with radiation therapy and chemotherapy. The patients in this phase two trial will also undergo procedures that generate a patient-specific vaccine that will be administered as part of the study protocol. Preliminary results have shown good tolerance of this intervention and encouraging tumor response.

Genetic Research Continues

In its mission to support research in brain tumors, the Brain Tumor Center is working with TGEN – the world renowned tumor genetic analysis study group in Phoenix, Ariz.

With the patient's consent, Abbott Northwestern sends part of the specimen from high grade tumors to TGEN for this important research.

Ongoing Projects at the Brain Tumor Center

These are examples of the important work happening at Abbott Northwestern. There are many new ideas and collaborations in process. Please feel free to contact John Trusheim, MD, at 612-863-3732 with questions regarding brain tumor treatment protocols. ■

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O-arm and Stealth Navigation, *continued from page 3*

like a GPS for the body, helping the surgeon visualize the surgical location on a scan. Previously, a CT or MRI scan was obtained before surgery and loaded into the Stealth Navigation computer. During surgery, the surgeon fully exposed the area of interest, manually registered 10 to 30 points by touching various areas of the spine with a probe, and then specified the corresponding locations via a computer on the previous scan.

Using the O-arm, the surgeon can perform surgery as before or make a small incision in the skin and place a reference probe on a spinous process or hip bone. During surgery, a C-shaped machine, which is draped to maintain sterility, is placed across the patient. The C is then closed around the patient forming a circle or O. CT scans are then obtained in a matter of minutes. The location and orientation of the reference probe is automatically detected and transferred to the Stealth Navigation system, and a current map of the spine is generated without exposing the area of interest and with an accuracy of about one millimeter.

This automation allows the system to be used for minimally invasive surgical applications. Its greater accuracy allows navigation near critical structures such as arteries or nerves. As a result, herniated disks can be removed, spinal narrowing can be relieved and percutaneous pedicle screws can be placed for minimally invasive spinal fusion, all using much smaller incisions. Less invasive surgery means smaller incisions, less tissue disruption, faster healing and less pain for the patient.

O-arm imaging can also be used for surgery to clearly define complex or abnormal anatomy (targeting lesions for brain biopsies or spinal tumors), and to adjust for "brain shift" during cranial surgery. Movement of important brain structures, or shift, often occurs during neurological surgery as spinal fluid is lost or as tumors are removed. The O-arm allows real time CT scans to be mapped to preoperative MRI scans to adjust for these differences. It can be repeated as needed throughout the case. ■

Sabrina M. Walski-Easton, MD, earned her medical degree from the University of Minnesota Medical School, Minneapolis, in 1998 and completed her residency at the University of Minnesota Department of Neurosurgery. She has been a surgeon with Neurosurgical Associates, Ltd. since 2006. ■