More Answers on Head Injury
Diagnostic Imaging at Southlake Regional Health Centre

"Good diagnosis is essential to good treatment."

A combination of new technology and incredible dedication from the staff in the Diagnostic Imaging department at Southlake Regional Health Centre in Newmarket provides answers to patients with traumatic brain injury.

Computed tomography (CT) is the standard imaging modality for patients with an acute head injury, whether mild, moderate or severe. CT scanning is a fast scan modality that quickly answers critical care issues concerning contusions, hemorrhages and skull fractures. Patients with a mild to moderate head injury may have a normal CT scan, but continue to experience symptoms that include headaches and cognitive changes. Very small and very deep micro-hemorrhages are not routinely visible on a standard CT scan, or, for that matter, on routine Magnetic Resonance Imaging (MRI) scans.

New developments in MRI are providing increasingly detailed neuropathological information that helps clinicians understand neurocognitive and neurobehavioural changes in patients following a head injury. This detailed knowledge of the injury severity (type, size and location of lesions) inevitably helps to better predict patient outcomes.

A recently introduced scanning application for neurological MRI exploits magnetic susceptibility differences between tissues by amplifying the magnitude of the signal given by injured areas containing any blood breakdown products (ferritin, deoxyhemoglobin, methemoglobin and hemosiderin).

The new application is called Susceptibility Weighted Imaging (SWI). It is 3-6 times more sensitive than traditional MRI methods for detecting small hemorrhages resulting from trauma to the brain, as in, for example, cases of diffuse axonal injuries (DAI). DAI is a common pathology found after a traumatic brain injury and is a major cause of prolonged functional deficits. DAI lesions reflect an injury to the continuity of the white matter in the brain. SWI is sensitive to DAI by detecting micro-hemorrhages that would otherwise go unnoticed. SWI makes it possible for the radiologist to see the size and number of very small areas of injury. Additionally the sequence is sensitive for examining small veins and any bleeding occurring in the white/grey matter boundaries.

Brain microstructure is evaluated using another technique at Southlake MRI called Diffusion Weighted Imaging (DWI). This technique provides information on cell health by sensing disturbances in the diffusion of water in the extracellular space and across cell membranes. The application of this technique focuses on the assessment of cerebral ischemia (lack of blood flow)

and infarction (tissue death due to the lack of oxygen). Abnormal diffusion appears as a result of a stroke, tumour, brain abscess or a traumatic event. DWI can detect cytotoxic edema (a fluid shift first into the intracellular space and then to the extracellular space of brain tissue) and therefore demonstrates hyperacute/acute (6 to 24 hours post injury) and acute/subacute (24 hours to 1 week post injury) cerebral infarctions. Thus DWI can identify acute infarctions and differentiate them from other chronic diseases including old chronic infarctions.

The examination also includes a look at the health of the vessels in the brain. Called *Magnetic Resonance Angiography* (MRA), this sequence produces a three-dimensional image of the vessels, enabling the radiologist to view the vessels from several different directions and check for aneurysms, blockages or any other disruptions.

While MRI examines the disruption of normal anatomy by traumatic brain injury, Single Photon Emission Computed Tomography (SPECT) imaging examines the disruption of normal brain function. SPECT is complementary to MRI because each can expose abnormalities that are not apparent on the other study. When taken together, they are a powerful tool for assessing traumatic brain injury.

SPECT provides insight into the function of the brain based on the uptake of an isotope tracer. A number of studies have been performed on patients with mild traumatic brain injury using technetium-99m labeled hexamethypropyleneamine oxime (99mTC-HMPAO) for SPECT imaging. Whether the injury is acute or chronic, SPECT examines patterns of cerebral blood flow and identifies areas of hypo-perfusion. The areas of hypo-perfusion (low blood flow) are associated with injury. Depending on the location, the identified hypo-perfused areas can help explain loss of consciousness, cognitive difficulties and cerebral atrophy.

From a patient's perspective, a deficiency in the amount of blood within the injured area signals a poorly functioning area and a generally unfavourable outcome.

At Southlake, patients benefit from both an MRI using the advanced techniques described above and a SPECT scan. The exams are done on the same day and interpreted together by one or two radiologists. The synthesis of MR (morphology) and SPECT (functional) information provides the clinician with a unique combination of information that has valuable prognostic implications.

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Suggested Further Reading:

Bigler, E. **Neuroimaging in Mild Traumatic Brain Injury.** *Psychological Injury and Law* 2010; 3:36-49

Neil, J. **Diffusion Imaging Concepts for Clinicians.** *The Journal of Magnetic Resonance Imaging* 2008; 27(1):1-7

Mittal S., Wu Z., Neelavalli J., Haacke E.M. **Susceptibility-Weighted Imaging: Technical Aspects and Clinical Applications.** *American Journal of Neuroradiology* 2009; 30:232-52

Mosely M. **Diffusion and Perfusion Weighted MRI.** *SMRT Education Seminars* 2007; 10(4);11-22

Prayer, L., Wimbeger, D., Oder W. Kramer, J. et al. **Cranial MR Imaging and cerebral 99mTc HM-PAO-SPECT in Patients With Subacute or Chronic Severe Closed Head Injury and Normal CT Examinations.** *ACTA Radiologica* 1993; 34:593-99

Runge, V. **Clinical MRI**, 2002, W.B. Saunders Company, Pennsylvania

Schonberger, M., Ponsford, J. Reutens, D., Beare, R., et al. **The Relationship between Age, Injury Severity and MRI Findings after Traumatic Brain Injury.** *Journal of Neurotrauma* 2009; 26:2157-2167