Discoveries on Magnetic Resonance Imaging (MRI)

2003 Nobel Prize Medicine

Cumulative discoveries in the field of Nuclear Magnetic Resonance paved the way to the development of the most advanced, safe, and non-invasive method in diagnostic imaging used in medicine today, the MRI or Magnetic Resonance Imaging.

These developments pioneered by Paul Lauterbur and Peter Mansfield gave them the recognition of their lifetime, the Nobel Prize in Medicine or Physiology in 2003. Together, they were able to develop a non-invasive method of visualizing bodily structures without the use of ionizing radiation.

Prior Advancements in Nuclear Magnetic Resonance

The first successful experiment in Nuclear Magnetic Resonance or NMR was conducted in 1946. Felix Bloch and Edward Mills Purcell showed that the resonance phenomenon is dependent on the simple relation between the intensity of the magnetic field and the frequency of the radio waves. Furthermore, they proved that for every type of atomic nucleus with unpaired protons, there exists a mathematical constant by which it is possible to determine the wavelength as a function of the strength of the magnetic field. The discovery was named Nuclear Magnetic Resonance because first, only the nuclei of certain atoms reacted that way, second, a magnetic field was required and lastly, because of the direct frequency dependence of the magnetic and radiofrequency fields. For this discovery, they were awarded the Nobel Prize for Physics in 1952.

During the late 1960s and early 1970s, a physician named Raymond Damadian showed that an NMR tissue parameter of tumor samples which he called T1 relaxation time, measured in vitro, was significantly higher

compared to normal tissues. He used NMR not as an imaging technique, but as a method for tissue characterization. His method help differentiate benign from malignant tumors. He was also the first to apply NMR technology to the field of medicine.

The Inventors and Their Contributions

Paul Lauterbur was born on 1929 in Sydney and during his childhood, he immediately developed a passion for chemistry. He graduated with a BS in Chemistry from Case Institute of Technology. After graduation, he began to learn about nuclear magnetic resonance from various visitors and speakers. This gave him the inclination to conduct researches about NMR technology.

Lauterbur's groundbreaking discovery was the imaging technique which he called zeugmatography. This imaging technique joins together a weak magnetic field with a stronger magnetic field allowing a spatial localization of two test tubes of water, one with ordinary water, the other with heavy water. He used a back projection method to produce a cross section image of tubes with ordinary water surrounded by heavy water. This made it possible to build up two-dimensional pictures of structures that could not be visualized with other methods. This imaging experiment moved from the single dimension of NMR spectroscopy to the second dimension of spatial orientation being the foundation of MRI. He then continued imaging living animals like tiny crabs and in the year 1974, he was able to image the thoracic cavity of a living mouse.

Sir Peter Mansfield was born on the 9th of October 1933 in London. At the age of 18, he developed an interest in rocketry. In 1956, he attended Queen Mary College, University of London and took up Physics. One of the projects assigned to him during those years was to develop a portable NMR spectrometer to measure the earth's magnetic field. It was because of this project that he became acquainted with NMR technology.

Sir Peter Mansfield was initially looking into using NMR to obtain complete structural details of crystalline materials via a similar field gradient scheme. In 1976, he further developed the use of field gradients in the magnetic field. He also developed a way to mathematically analyze the feedback signals and transform the data into an image. He named this extremely rapid imaging technique echo-planar imaging.

What Do We Know Now About MRI

Magnetic Resonance Imaging or MRI is now considered as the most powerful, most sensitive and safest method in medical diagnostic imaging. Unlike its predecessor, the CT and X-ray, MRI does not use ionizing radiation making it perfectly safe for the patients. MRI can image literally any internal part of the body but it is specifically used to evaluate organs of the chest and abdomen, the pelvic organs including the reproductive organs, blood vessels and most especially the human brain and spinal cord.

How does it Work

A great majority of our body is composed of liquids more specifically, water. Each water molecule if composed to two hydrogen nuclei. When a patient enters the magnetic field of the MRI [1], the magnetic moments of the protons in the hydrogen nuclei align with the field. A radio frequency transmitter is then turned on to produce an electromagnetic field. The photons in this field have resonance frequency to flip the spin of the previously aligned protons. The field is then turned off to allow the protons to return to their original state and the difference in energy of the two states of the proton is released as a photon. These photons are then detected by the scanner. Images are formed because the protons in the various tissues of our body return to their original states by releasing various amounts of energy at different rates.

MRI's Immediate Use in the Field of Medicine

Starting from the 1980s, the use of MRIs became widely spread in the field of medicine. In the year 2002, more than 22, 000 MRI were already in use worldwide and more than 60 million examinations using the MRI were already performed. This success of the MRI as a diagnostic imaging technique is attributable to its effectiveness and safety.

MRI has been proven valuable in diagnosing conditions like cancer, heart and vascular disease, muscular and bone abnormalities and brain/spinal cord abnormalities. It is also an outstanding preoperative tool since with an MRI; surgeons can already locate the lesion within the body of the patient even before starting the surgery. It also reduces the discomfort of patients especially in cases like pancreatic and bile duct abnormalities.

The only downside of the use of MRI is its high cost compared to the much cheaper X-rays and CT Scans. Also, patients with metal in the body or pacemakers cannot undergo MRI because of its magnetic nature.

Links
[1] http://en.wikipedia.org/wiki/Magnetic_resonance_imaging