CURIOSITY-DRIVEN RESEARCH

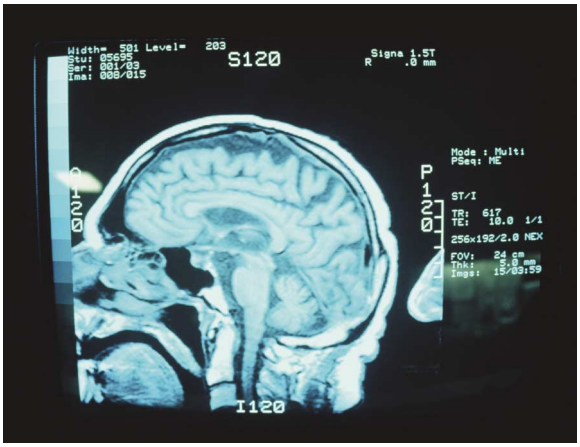
MRI

MAGNETIC RESONANCE IMAGERY

- The product of more than 70 years of research in a field awarded several Nobel Prizes
- MRI is able to create detailed images of the brain to assist with the diagnosis of conditions such as multiple sclerosis and Alzheimer's disease
- Peter Mansfield working at the University of Nottingham carried out research that is instrumental to rapid imaging

What is it?

Over the past 20 years, medical imaging techniques have given doctors the ability to see what is happening inside the human body without having to resort to surgery, saving patients pain and doctors time. Foremost among these techniques is magnetic resonance imaging (MRI). The product of more than 70 years of research in a field awarded several Nobel Prizes, it allows doctors to diagnose, and so treat, patients more rapidly and more effectively. Using a combination of very strong magnets and radio waves, MRI is able to produce high-resolution images of the opaque interior of the body.



Though it is capable of imaging almost every part of the body, MRI is most commonly used for examining the brain. Whereas X-rays cannot distinguish details or structures and surgery is regarded as being too dangerous, MRI is able to create detailed images to assist with the diagnosis of conditions such as multiple sclerosis and Alzheimer's disease. As an emergency medical tool, MRI has the ability to detect and diagnose strokes quickly, limiting damage and allowing immediate treatment, so promoting recovery. As a research tool it has allowed doctors to see the inner structures of the brain, imaging the effects of thought processes, to see how it responds to stimuli and manages emotion.

MRI is in many ways the ideal medical imaging technique. It can identify all kinds of tissue, poses no health risks and has no limit to the number of images that can safely be taken. Patients require no preparation and there is no recovery time. Designed through collaboration between the University of Nottingham and British medical instruments firm EMI, full-body MRI scanners were first introduced to hospitals in the early 1990s. There are now more than 20 000 machines around the world performing more than 60 million scans on patients every year. MRI is now a standard diagnostic tool in a large number of hospitals, improving treatment, cutting waiting times and saving lives.

The science

The ability of MRI scanners to produce images of the human body is due to a fundamental property of atoms: that they respond to magnetic fields.

I I Rabi first observed the phenomenon in 1946 in work that won him a Nobel Prize. Research has continued and new developments are still taking place today.

MRI creates images using the magnetic properties of the simplest of all atoms – hydrogen. Nearly two-thirds of the atoms in the human body are hydrogen atoms and they are found in all parts of the body, concentrated in water and fatty tissue. An MRI machine is constructed from very powerful magnets, around 60 000 times as strong as the Earth's magnetic field, inside which the patient lies. In such a strong magnetic field, hydrogen atoms in the body become aligned in a particular direction, parallel to the direction of the magnetic field. A short pulse of radio waves is used to "nudge" the atoms away from this alignment. When the pulse stops, the atoms realign to the field with the emission of more radio waves. The characteristics of these waves will depend on the kind of tissue that the hydrogen atom is in. Detection and analysis of these radio waves can determine the precise nature of the environment of the atoms. Using a magnetic field that varies in a carefully controlled way, an MRI machine can divide the body up into regions of about 1 mm across and measure the properties of the tissue in each of these regions.

Peter Mansfield working at the University of Nottingham devised mathematical methods that allowed the emitted radio wave signal to be rapidly analysed and transformed into three-dimensional images of the body. The instrument can be configured to distinguish between all types of tissue, allowing detailed images of organs such as the brain to be acquired and for the images to tell the difference between healthy and cancerous tissue.

MRI timeline

1945	The first magnetic resonance measurements are taken of a solid
1950	The invention of pulsed magnetic resonance
1959	J R Singer at AT&T Bell Labs proposes MRI as a blood-flow measurer
1971	Paul Lauterbur devises a way to create magnetic resonance images
1973	Lauterbur produces the first magnetic resonance image
1973	Peter Mansfield at the University of Nottingham publishes a method to construct images quickly
1976	Mansfield produces the first magnetic resonance image of a body part
1980	The first useful image of a patient in a hospital is taken
1986	Technological advances mean that it takes less than 5 s to obtain an image
1990	Full-body MRI scanners are introduced into hospitals
1993	Functional MRI is developed, enabling the brain to be imaged in great detail
2002	20 000 MRI machines exist in the world and 60 million examinations are performed
Today	Scientists are working towards combined MRI scanners to produced real-time images of internal organs

Advancing surgical accuracy

Other advancements in MRI are centred on use during surgery, to allow doctors and surgeons to have a constantly updated, three-dimensional map of the patient they are treating. One way of accomplishing this is to fit robotic arms on the inside of the MRI machine. These are guided by doctors via remote control and can be used to take tissue for medical testing from precisely the right point on a tumour. Currently doctors working from a static MRI image cannot be sure that they have collected tissue from the tumour rather than surrounding material and often take multiple samples to be sure. This method would speed up the process and cause less distress to patients.

Magnetic attraction of MRI

MRI is able to distinguish between types of tissue owing to the extremely strong magnets and very sensitive detectors that it uses. The use of such strong magnets means that magnetic materials should not be placed near the MRI machine because they are likely to be strongly attracted to it, flying through the air and potentially injuring doctors or patients. For this reason the doors to many MRI suites are fitted with metal detectors. The strong magnetic fields also mean that if a patient already has something containing metal in their body, such as a pacemaker or screws attached to bones, the metal may move while inside the magnets, causing some discomfort. Some kinds of tattoo inks contain extremely small quantities of metal and such is the power of the magnets that even patients with these cannot have MRI scans.

Future developments

New developments in MRI technology involve combining it with other medical imaging techniques such as CT and PET. Exploiting MRI's extremely high resolution and great sensitivity, and using the ability of the other techniques to image fast-moving processes, the new combined machine can image almost any system in the body.

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