Picture of the body in fine detail

A revolution in MRI scanning – fast field-cycling – is underway at Aberdeen. **Jennifer Trueland** reports

WORK has begun in Aberdeen to build an entirely new type of scanner which could represent a tremendous leap forward in MRI technology. The new machine is being designed to give an unprecedentedly sensitive and detailed picture of the human body by providing information that is simply not available with existing magnetic resonance imaging (MRI).

Called fast field-cycling MRI, it has the potential to diagnose conditions earlier and more accurately as well as improving knowledge of disease processes.

The work is being taken forward with the help of a £2.4m grant from the Research Council UK's "Basic Technology" scheme.

David Lurie, Professor in Biomedical Physics, is heading the project team which includes physicists, engineers, chemists, medical scientists, biologists, radiologists and three industrial partners.

Indeed, it was a brainwave of his, putting together various ideas and strands of existing research, which was partly responsible for the project in the first place.

Conventional MRI, which has been around for the last quarter century, has itself revolutionised the way we diagnose conditions by creating detailed images of the body. Essentially it involves creating a powerful magnetic field which "lines up" the hydrogen molecules in the human body, which themselves act like tiny bar magnets.

Once the body is in the scanner, short bursts of radiowaves are applied. At the right frequency, these have the effect of making the hydrogen molecules turn around by giving them extra energy – the "resonant" part of the name.

But, according to Lurie, this is like rolling a ball up a hill; the hydrogen atoms do not want the extra energy so they expel it and bounce back, or "relax", to their original position. The length of time that this takes to happen is significant, however, as it depends on the type of tissue – a kidney takes a different time to a liver, for example – and, crucially, on whether the tissue is healthy or not.

It's like being able to use up to 100 MRI scanners at once

All this information is gathered into the image produced by the scanner, which can then be compared with the norms, or what would be expected from healthy tissue.

MRI has developed in the last 25 years, but still has limitations. One of these is that each scanner can work with only one, unvarying, strength of magnetic field.

Relaxation speeds change depending on the strength of the magnetic field and there is a growing belief that this information can be used to get an even more detailed picture of what is going on in disease processes.

"A lot of people now think that the way that tissues relax in different magnetic fields may be a new way of diagnosing diseases," says Lurie. "But it's impossible to do that in one machine.

"A person would have to go into 50 or 100 different machines to get meaningful data which wouldn't be pleasant for them and it wouldn't be practical – most hospitals will have only one or two MRI scanners.

"That's where fast-field cycling [being able to switch magnetic fields in one machine] is coming in."

What the Aberdeen researchers have done is combine the technology of the traditional MRI scanner with that of the relaxation spectrometer, a piece of equipment which uses fast field-cycling with small, specialised magnets, to examine tiny samples of tissue.

"We're building a machine using very specialised magnets which will be able to shift magnetic fields, switching to between 50 and 100 values," says Lurie.

"It's like being able to use up to 100 MRI scanners at once, each one using a different magnetic field, but in the one machine.

"The new scanner will be able to switch magnetic fields while the image is being taken, which will allow us to gather information about how the molecules of the body react in different magnetic fields."

This additional layer of information is likely to be particularly useful in discerning how the proteins in the body react and interact. Proteins (and their malfunctions) are hugely important in many diseases, including Alzheimer's, Parkinson's, multiple sclerosis, cancer and a range of inflammatory conditions.

Potentially it will lead to earlier diagnosis, allow the disease's progress to be charted more accurately – showing whether a treatment is working, for example – as well as improve our understanding and knowledge of the disease process.

The machine has other potential applications, too. The team has already had interest from a food company, which wanted to find out more about whether it could give information about what happens to the protein in food during processing.

It could also be a terrific boon for sports medicine by allowing muscle mass to be gauged without using invasive techniques such as biopsy.

The project happened almost by chance. Scientists at Aberdeen had already been working on a similar prototype scanner with the idea of being able to track harmful "free radicals" in the body. At a meeting in Berlin in the late 1990s, Lurie saw some work on the idea of rapidly switched magnetic fields being a route to measurement of protein. Recalling the free radical project, he decided it was an approach worth investigating.

A pilot study funded by the Leverhulme Trust showed positive results, then the latest four-year project to build two new scanners, a smaller one as a test bed, then a larger, full-body scanner, began in May 2007.

Hardly surprisingly, researchers at the University of Aberdeen's Institute of Medical Sciences and the Institute of Applied Health Sciences are excited about the possibilities brought by this new machine, being built on their doorstep, and are playing an active role in the project.

The team has three industrial partners: Invento, a spin-out company from the University of Turin in Italy, which has expertise in developing MRI contrast agents; Tesla Engineering in Sussex, which is developing the specialised magnets needed in the new machine, and Oxford Instruments, manufacturer of MRI scanners, which is working on the special control system for the new machines.

There is, however, a particular poignancy in the location of the new machine. It was in Aberdeen in 1980 that the very first patient was scanned using MRI. Now it looks like the city will also spawn the next generation of scanners. ■

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Picture: Graham Jepson

David Lurie: A brainwave of his was partly responsible for the project