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Hello and welcome to the Health Hits podcast.

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This time we're talking about MRI or Magnetic resonance imaging. We'll look at how these amazing scanners work, what they can see, and some of the problems that come from working with magnets that are 50 thousand times stronger than the Earth's magnetic field.

This episode uses quite a few technical terms, which I will explain as we go, but the text of each episode is available on the site HealthHits.info under the 'Listen Now' tab.

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I'm Tom Fisher and I'm a doctor working in Oxford in the UK.

There is nothing more fascinating than the human body. How it works and how it can go wrong. I research and present this podcast with the aim of removing some of the mystery around common medical conditions. Along the way we will encounter the unusual, the bizarre, as well as exploring medicine from the past and in the future.

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So MRI.

I'm a medical doctor and ask me any question about the human body and I'll likely have a pretty good idea of where to start. Ask me to look at an MRI scan and I'll likely have a pretty good idea of what it shows. But how an MRI works is not something I had ever considered before researching this podcast. It's complicated but I'm going to try to explain how it works in the same way that I have come to understand the process from my own reading and I was also lucky enough to pick the brains of a top London radiologist.

The process involves complex electromagnetics, radiofrequency, computing and mathematics, but essentially what it does it converts a series of signals into a grey-scale image that a doctor can interpret.

How do we get the signal in the first place?

Our body is made of 65% water which contains hydrogen atoms, and that's what they use to get the signals, which are ultimately converted into an image.

You can imagine these hydrogen atoms bumbling about in the water our tissues. Our bone, skin, muscle, organs, blood.

I like to think of them like soldiers milling about on a parade ground. Bumbling about like toddlers, in no particular direction.

The first stage of getting a signal is applying a magnetic field to the body and so to the hydrogen atoms. This is generated by powerful electromagnets around the tunnel that you lie in when you have the scan.

All hydrogen atoms have a very weak magnetic north and south pole, so when you apply the strong magnetic field they all line up. In my parade ground analogy you could think of it like the soldiers moving from milling about to standing to attention, all facing towards their sergeant major. Sergeant Major Magnet.

This is the first stage. The hydrogen atoms in the body are all lined up, but that doesn't help so far.

The second and most important stage is that a radiofrequency pulse is applied to the atoms. This is basically an invisible wave, similar to those that carry signals to your car radio.

What it does is knocks the hydrogen atoms onto their sides, or in the case of our soldiers, knocks them down to the ground.

When the radiofrequency pulse is removed, the hydrogen atoms start returning to the upright position, back into alignment with the magnet.

Some have more energy and return quickly, some have less energy and return slowly. The energy they have depends of what sort of body tissue they are in. The amount of water in bone and in muscle is different so will create a different signal.

A signal is generated when the atoms return to upright, or the soldiers return to standing, and is picked up by detectors.

These signals are collected in slices, then very clever computing techniques assemble the layers into a 3 dimensional structure and displays them in greyscale so that lighter and darker greys represent different body tissues.

If you had a lump in your body and you weren't sure what is was, MRI should be able to tell you whether it is a simple cyst full of watery fluid, a fatty lump, or a much denser tumour. The grey colour should look very different in each of these cases.

So that is how the scanner works, and how the images are generated. The scan is performed by specialist technicians called radiographers, and accurately interpreting the images is done by an imaging specialist doctor called a radiologist.

In medicine we spend our time looking directly at patients as we examine them, so the right side of their body is on our left and the left side of their body is on our right. MRIs are usually displayed in the same way, with an image of a particular slice of the body being show with the right side of the patient's body of the left of the image and left side displayed on the right. This can be incredibly confusing when you first start to look at medical images.

I decided to create this episode in tribute to English Physicist Sir Peter Mansfield who has sadly passed away very recently. He shared a Nobel Prize in 2003 with Paul Lauterbur.

Together they pioneered the MRI imaging technology. The first human MRI image was taken of Sir Peter's research student Andrew Maudsley in 1976. Specifically his finger.

By 1977 American doctor Raymond Damadian was well on his way to producing a whole body scan.

During the research for this episode I have been struck by just what a remarkable achievement it was for these pioneers of such a complicated field.

The technology continues to improve with greater and greater image resolution and clarity. It is a fantastic scan as it gives great detail, especially about the soft tissues of the body. CT and Xray often fall short here, and are much better suited to imaging hard structures like the bone.

Despite using scary sounding electromagnets and radiofrequency pulses, the MRI is completely safe to human tissues. People are often anxious about having the scans because of two things; lying in the enclosed tube of the scanner, and the loud banging it makes.

The magnetic field is used to align to hydrogen atoms and making the magnetic field creates the banging. The magnet is an electromagnet, which forms when electricity runs through copper coils.

The amount of electricity used is so strong that the copper coils expand slightly and then contract, and these movements make the banging sound. It is not harmful directly but since it can be as loud as a chainsaw or a hammer banging on a nail, ear protection is given. These headphones often play music.

The tube in which you lie can be narrow and if you are prone to claustrophobia, like me, it can be unpleasant. A variety of things can help combat that, such as breathing exercises, music and mirrored glasses that give a

sense of openness. Sedating drugs can be used in severe cases as the scan can last up to an hour and will not work properly if you move. I have added a link to a great article on MRI claustrophobia to the resources library on HealthHits.info

Children or disabled people may struggle to with keeping still or just simply being in the machine. Sometimes it is necessary to anaesthetise someone so they are completely unconscious in order to get decent images safely.

This has given rise to a whole new field of anaesthetics, as you are limited with what you can actually take into an MRI scanner room due to the powerful electromagnet. A magnetic force 50 thousand times more powerful than the earth's will pull anything metal towards it. I have seen images of large oxygen cylinders, wheelchairs, even beds stuck to MRI scanners. And not just stuck but lifted clean off the ground.

So you can imagine that the usual array of metal needles, scopes and monitoring equipment in an anaesthetist's kit would be that last thing you would want to take into a MRI scanner.

Staff and patients cannot take anything containing metal into the room, including watches, rings, necklaces, hearing aids, bras.

Any metal inside the body can cause serious harm when in the magnetic field. For example metal shards in the eyes, metal clips clamping off arteries, metal dental fillings, pacemakers, could all move and this would be disastrous.

Knee and hip implants have generally been considered safe as they are anchored within bone, and more modern joint replacements use the non-magnetic titanium.

That's all I can think to talk about on MRI for this episode. I have uploaded a graphic showing the images an MRI scanner can produce onto the website www.HealthHits.info. There you'll find all the episodes in audio and text format, my resources library and you can leave suggestions for future episodes.

You can also ask questions and make suggestions, as well as accessing all the resources at www.facebook.com/healthhitspod and on twitter @HealthHitsPod.

Thank you so much for listening and please join me again for another episode of Health Hits.