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MRI

RADIOLOGY: THE ADVANCED MODALITIES

Magnetic Resonance Imaging (MRI) – Part 1 of 2

What Is MRI?

Magnetic resonance imaging (MRI), previously referred to as nuclear magnetic resonance, uses a magnet and a radiofrequency (RF) wave to manipulate the atoms in the body and thus differentiate various tissues. An MRI machine is basically a microwave and a magnet. (Yes, your body temperature rises slightly when you are in the magnet.)

Hydrogen atoms are very abundant in the human body, because they are a part of the water molecule and our bodies are largely composed of water. Hydrogen atoms are charged particles, so they will align with a magnetic field. In MRI, we use the magnet and RF wave to "flip" these hydrogen atoms (otherwise known as protons) in different directions.

EQUIPMENT

The Parts of an MRI Machine

• The main magnet

- In most MRI machines, this magnet is always on. Thus, whether a patient is being scanned or not, precautions are always taken to keep metallic objects away from its powerful magnetic field.
- Most magnets used today have strengths ranging from 0.1-3.0 Tesla. Stronger magnets generally allow for better resolution on images, because they produce a stronger "signal" (see below), but they tend to be more enclosed.

• The gradient magnet

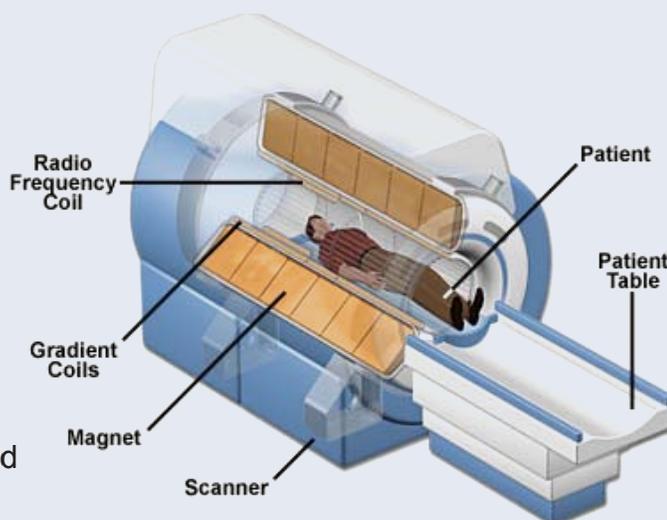
- This component allows more specific "tweaking" of the magnetic field, making the field slightly stronger in some areas and slightly weaker in others. This is what allows the machine to focus on specific areas in the body. This is also the part of the machine that makes a loud banging noise during an MRI scan. The gradient magnet controls the excitation location and thickness of the slices.

• The coil

- This emits the RF excitation pulse and is placed near the part of the body that is being imaged. Different-sized coils are made for different body parts. The coil can be used to produce the signal for excitation, but also may function as the detector of signal after relaxation (the echo).

The shim coils

- These are used to "tweak" the magnetic field, to keep it homogenous, and make the images as consistent and accurate as possible.



MRI BASICS

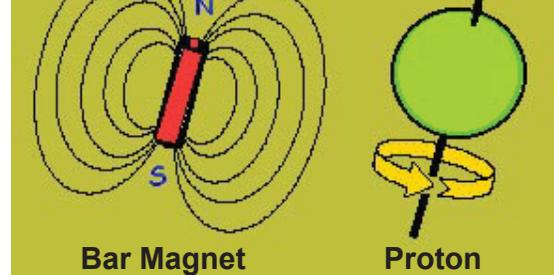
How It Works

First, the patient is put inside the MRI machine, which is essentially a very large magnet. Normally, hydrogen protons are randomly oriented. After the

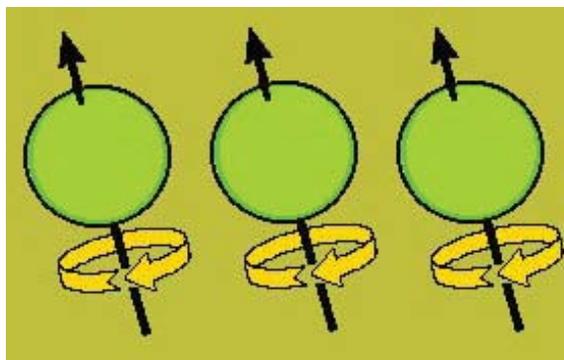


patient is put in the magnet, the protons in the patient's body align in the same direction as the magnetic field.

Next the matched frequency RF waves (or "pulses") are emitted from the coil. The RF (radio waves) must have a similar frequency to the protons they excite; this is called a resonance match. If there is no frequency match, there is no effect – thus the term "resonance" in MRI. The radio waves flip the protons in a specific direction – for example, 40 degrees, 90 degrees, or 180 degrees. All the protons will then be pointing in that direction.



Protons generate a magnetic field similar to that generated by a bar magnet.



RF pulses from the MRI coil "flip" the direction of the aligned protons.

So, how do we tell different substances in the body apart? We wait: After the RF pulse is applied, each proton will "relax," meaning that it will go back to its original position, aligned with the large magnet. Protons in water will relax at different speeds than those in fat. As they relax, they emit an electromagnetic wave, or "echo," that can be detected. Radiologists use these differences in "relaxation times" (the speed of recovery) to tell different tissues apart. By varying the strength and timing of the RF pulses, we can make varying pulsing sequences, which accentuate different tissues.

MRI vs. CT

How Is MRI Different from CT?

Magnetic resonance imaging is similar to CT, in that they are both non-invasive ways to see inside the human body in great detail. The views, or planes of imaging, are also the same as those in CT -- axial, sagittal, coronal, and oblique (angled) – see the last issue for details.

MRI is very different from CT in most ways, however. For example, large proteinaceous structures like fat (fast relaxers) behave very differently than small molecules (slow relaxers) like water. Other differences include:

- **MRI involves no harmful radiation.**
 - It is obtained using a magnet and waves similar to those used for radio and television broadcasts.
- **MRI is not dependent on tissue density.**
 - The appearance of substances on CT is dependent on their density; dense tissues such as bone are white, and less dense tissues like fat and air are dark. However, in MRI the appearance of substances depends on many factors, including their water and fat content, how they are bound, and the MR imaging technique used.
 - Thus, an area that is bright on a CT image is referred to as "hyperdense," while a bright area on an MR image is called "hyperintense."
- **The spatial resolution of MRI may be less than CT for some applications.**
- **MRI has a better ability to differentiate various substances, especially soft tissues and the brain.**
- **MRI is much more time-intensive, both to perform the scan and to read.**
 - Reading the scan can take longer because of the many pulsing sequences that are used. Therefore, more images are available for review.

NEXT WEEK: MRI, Part 2