Ultrasound Imaging

So far we have considered the use of X-rays which are part of the electromagnetic spectrum. Ultrasound imaging, as the name implies, uses sound waves instead at the 3 to 20 MHz range, which are beyond the audible range (20 to 20,000 Hz) i.e. we cannot hear them. This is not, therefore, using ionising radiation. This technology is based on the properties of crystals and the piezo-electric principles which basically refer to the ability of certain crystals to change their shape and produce a voltage potential. As the sound waves travel through tissue, there will be both attenuation and reflection. Attenuation refers to the loss of energy due to absorption, reflection and refraction by the body. Reflected sounds waves are used to produce an image, and depends on the acoustic properties of the reflecting tissues.

The machine, very simply, sends in a sound wave and then “listens out” for the echo of that sound wave as it bounces off a structure and returns to the receiver. The change between the sound waves transmitted and those received can be used to determine the depth and properties of the reflecting structure.

The sound waves used are not of high energy as in X-ray imaging which means that the depth to which the waves will penetrate the body is limited. Fluid is especially good at transmitting ultrasound waves.

Radiologists (i.e. imaging doctors) may perform ultrasound scans especially on complex cases and in situations when ultrasound is used to guide an invasive procedure such as inserting a drain into the chest or abdomen.

Antenatal scans tend to be performed by specialist antenatal staff. Sonographers are the radiology equivalent of a radiographer and will be technicians (not doctors) specifically trained in the art on performing ultrasound scans on all parts of the body.

Questions

Ultrasound is a poor choice for imaging the lungs. Why? Imaging obese patients by ultrasound can pose a problem. Why?

Doppler imaging is a useful addition to standard ultrasound to obtain information about blood vessels and uses the principles of the Doppler shift. What are the principles of Doppler shift and what information in particular can we gain about blood vessels in this context?
MRI – magnetic resonance imaging

An alternative to CT is magnetic resonance imaging. This method, like ultrasound, does not utilise high energy ionising waves. Instead, as suggested by the name, it involves the use of powerful magnets but also radio waves. The physics of MRI is mind-bogglingly complex. In a nutshell:

All of the hydrogen atoms in the body contain protons in their nuclei which possess fundamental magnetic properties. When exposed to a strong electromagnetic fields (e.g. Typically between 3 and 9 Tesla) those protons can behave like tiny magnets and will align accordingly. They can be thought of at this point like tiny spinning tops, all rotating around an axis and aligned in the same direction. This is the first step in the process.

Once a steady state of magnetism within the human body is achieved the protons are disturbed from their steady state by the introduction of radio waves. It’s like giving the spinning tops a little shove to make them wobble or flip. Next the MRI machine stops the radio waves and the protons start to settle back into their steady state. As they recover from their little upset, they send out radio waves. These transmitted radio waves are used to construct an image of the body by computerized tomography… so it could also technically be called CT, just to confuse the issue!

In addition, protons will behave differently depending on their chemical environment and the levels of certain molecules, such as neurotransmitters, can be assessed using magnetic resonance spectroscopy. Functional MRI (fMRI) makes use of other magnetic substances in the body such as haemoglobin which has different properties depending on whether it is oxygenated or deoxygenated.

Questions

Patients with pacemakers fitted are not able to have MRI scans performed. Why not?

Why are patients asked about the presence of metallic objects in their body before having MRI?