Program: Understanding Magnetic Resonance Imaging (MRI)
Speakers: David DeBrota, MD, Vice President for Medical Research and Development, Perspectum Diagnostics, LLC; Oxford UK; Dallas, TX; San Francisco, CA; Scientech Club member
Introduced by: Hank Wolfla
Attendance: 100 via Zoom and the current Zoom limit for Scientech Club
Guests:
Scribes: Carol and Jim Mutter (a.k.a. the Mutter Marines)
Editor: Carl Warner

Dr. Dave DeBrota is a Scientech Club member and invited questions to his email: Debrota@Hotmail.com

Also the session was recorded and is available on the Scientech Club web site: https://www.scientechclub.org/zoom/474.mp4. It can be shared with others.

MRIs are so advanced, complicated and technically sophisticated they are almost like magic.

MRI machines are not silent, they make lots of noises. Each has a very powerful magnet that switches on and off quickly, generating a vibration in the metal causing noises. Ear plugs are recommended. Most of the MRI scanners are circular tunnel-like structures, and the patient slides in on a table. For those who may be claustrophobic, there are some scanners that are open on the sides with just a flat table between top and bottom machine surfaces. Dave's slides included photos of sample MRI images including one in color.

MRIs are a tremendous advantage in the treatment of individuals; consider that care giving used to rely on no internal pictures at all or just x-rays (differences discussed below). There are even whole-body MRIs that can cut the data in different ways and images "stitched" together for a single picture.

MRI images are made up of "voxels" – which are volume elements (or 3D pixels). They are usually about the size of a grain of rice, but can be smaller. One Voxel has about 10 million trillion protons. The protons are key to the image.

There's a good slide (slide 9) in Dave's presentation titled Electromagnetic Radiation that shows the wavelengths for various medical imaging techniques.

History of MRI begins in 1960s – when a Soviet Union scientist registered a patent. But it was the early 1970s before thoughts were serious about MRI. The CT scanner came first. An MRI was first used on a human in 1977. Many were installed in the early 1980s. As computing power increased, the use of MRIs could increase also. Plus the development of super conducting magnets was also necessary.

Photons are also key to MRIs. We all have many millions of photons that bombard our bodies every day all day long. Many pass all the way through but some are absorbed. They have a property called resonance, and different types of photons have different frequencies which can be used to identify different types of tissue and issues with tissue (e.g. cancers). The small protons act as small magnets.

An MRI scanner uses 8,000 watts to keep its magnet cold; while scanning and switching off and on it can generate/use up to 1,500 kilowatts! Magnetic fields are generated from coils (see slide 17 at about 30 minutes into the recording). Two opposing magnetic fields generate a magnetic field gradient which is used by MRI machines which have many different coils and can generate a different magnetic field in every spot in the body because of the magnetic properties of the protons.

Protons "precess" – they are spinning in a magnetic field which emits photons of an exact frequency. They can spin either clockwise or counter-clockwise. There's also a chemical shift in the magnetic field that affects the protons and also electrons. This is what tells us what kinds of tissues those molecules are a part of. See slides 23 through 26 in the video. The MRI interrogates the protons with the photons. Got it???? Listen to the video and then email Dave! Not the scribes!

X-rays in a CT scanner take many pictures of slices of the body from different directions. An MRI scanner uses magnetic field gradients switched on and off at precise times and RF pulses of specific frequency duration and timing. Echoes from the pulses are picked up in a receiving coil and analyzed for information about the tissue.

Relaxation is a term used for different molecules in different tissues – see the numbers in slide 31. There are different effects on protons which are used in diagnosis. Slide 32 shows the difference between a CT (x-ray) scan and an MRI.

Conspicuity is the ability to see something in a still image using contrast, noise, and/or resolution (# of pixels). Slide 34 shows how the CT scanner builds an image. Slide 35 shows how the MRI scanner builds images. Knowing how to mix spatial frequencies comes from the echoes and generates a good picture for analysis. Slide 36 shows different MRI images created from the various numbers that are received from a single voxel. The CT scan shows just one view based on the tissue density.

The MRI picture can also be colored to show additional info (e.g. scarring, amount of iron or fat in the liver, for example (see slide 37).

A CT scan is much faster, but there are radiation risks with x-rays.

MRI uses an amazing amount of power, but regardless of time in the magnet, the risk is minimal – lower than a CT scan. MRIs are used for musculoskeletal issues. Some MRI studies require gadolinium injections to increase tissue contrast in your body, which can be a higher risk.

MRIs should not be used on patients with metal or electronics in their bodies because of the strong magnetic fields. Some very weak magnetic field scanners are available, but they generate less information.

Scanners can cost from $1M - $10M.

Dr. Dave DeBrota