MAGNETIC RESONANCE IMAGING -- DEFINITION

Magnetic resonance imaging is the creation of highly detailed anatomic images using strong magnetic fields, radio frequency waves, and computers.

The emergence of magnetic resonance in the field of diagnostic medicine has been heralded by many as potentially the most important achievement since the discovery of x rays. Until now, the only methods of acquiring images from inside the human body involved the use of ionizing radiation, radioactive isotopes, or ultrasound waves.

In other modalities, the body is an attenuator, reflector, or vehicle for emissions that are picked up by some type of receptor. In MR, the nuclei of atoms in the body themselves create the image. In contrast, for instance, in an x-ray film or a computed tomography (CT) image, structures such as bones and organs attenuate, or block, a beam of x rays passing through the body. The x rays interact with the electrons in the body's atoms.

In ultrasound, body structures reflect sound introduced into the body. The returned signal is used to form an image.

In nuclear medicine, body structures are vehicles for storing radioactive isotopes whose emissions are detected, allowing molecular or organ function to be viewed. All of these scans or tests require the introduction of ionizing radiation, radioactive isotopes, probes, or other devices into the body, and are considered invasive procedures.

MRI, on the other hand, is in itself a noninvasive procedure, although contrast agents sometimes are injected. MRI actually uses strong magnetic fields and radio-frequency waves to create an image based on the atoms of the body itself. Physicians can view fine, detailed anatomic structures in order to identify normal or diseased tissue and to interpret pathologic (abnormal) changes. MRI can also be used in conjunction with invasive procedures.

MRI's many advantages include:

- No ionizing radiation
- No known biological hazards

- O High-resolution isotropic images (3D images in which all three dimensions are equal)
- O Excellent soft-tissue contrast
- O Opportunity to interpret pathologic changes
- O Usually noninvasive

Basic atomic and molecular structure will be discussed in Module 3, MR Fundamentals; but let's look at a brief overview of how magnetic resonance imaging works:

Atomic nuclei in the body act like tiny bar magnets with north and south poles. When the body is placed in a strong magnetic field, some of the little magnets line up with the powerful external magnetic field.

Then, when radio waves (one form of energy) are passed through the body, some of these little magnets absorb some of the energy and change direction ("resonate"). When the radio waves are turned off, the body's atomic (not cell) nuclei return to their original orientation, releasing the absorbed energy. The energy forms a signal that can be picked up by an antenna and processed by a computer into an image.

That image is a precise representation of anatomic structure. Because the manner in which the atomic nuclei return to their original position is characteristic for different atoms, the image created on the basis of that movement lets the viewer discriminate between many different types of tissue – normal tissue, lesions (tissues that have undergone pathologic change), and tumors (abnormal growths). Understanding this property of MR imaging is key to understanding how MR works and why MR systems are clinically so important.

Clinical MRI scans use hydrogen nuclei (protons) to form the image. Ninety percent of the body consists of H_2O (water), with two hydrogen atoms per molecule. This abundance of hydrogen atoms permits reception of a strong signal. Many pathologic conditions are associated with accumulations of water, and therefore emit a strong signal.

MRI data can be acquired slice by slice, through the body; or by taking multiple slices simultaneously. (A slice is a location within the selected anatomic structure, just as a slice of bread is a portion of a loaf.) The exciting feature of MR imaging over other modalities is the ability to acquire images directly in any plane, without moving the patient or placing the patient in an awkward position. Volumetric techniques allow a "cube" of data to be acquired for retrospective reformation of any plane.

The three most common planes are axial, sagittal, and coronal. The figures below (Figures 1-3) show examples of images in each plane.