MRI SAFETY MATTERS®

Content of Dr Kanal's 4th European MRMD/MRSO MRI Safety Training Course, 3rd to 5th June 2024

Static Magnetic Fields, Part 1 and Part 2

The interaction of static magnetic fields on paramagnetic and ferromagnetic materials is dependent not only upon the static magnetic field strength itself but also the magnetic spatial gradient, or the rate at which the magnetic field changes across space or across a device or implant or foreign body. The relative spatial distribution of these forces - where they are greatest and where they are weakest - will be reviewed and the clinical significance of these forces and spatial distributions will be clarified. Emphasis will be placed on translational forces and comparisons with rotational or torque related forces will also be highlighted. The roles of the static field and the static spatial field gradient in generating the force product will be introduced. While translational and rotational forces can be exerted by magnetic fields on ferromagnetic materials, Lorentz forces, related to Lenz's Law, can be exerted on any electrically conductive material. A discussion of Lenz's Law, what causes the clinically discernable Lorentz forces that result from it, and how to safely manage them, will be presented.

RF Magnetic Fields: Diffuse Power Deposition

Each RF pulse transmitted by the MR scanner deposits energy into the patient. The relationship between such RF pulses and patient core temperature is discussed. Mechanisms of human thermal autoregulation are also reviewed and their importance in MR imaging environments is emphasized.

RF Magnetic Fields: Focal Power Deposition/Burns

While diffuse power deposition from RF pulses is exceedingly unlikely to cause any harm, focal RF power deposition, or burns, are the most common non-pharmaceutical based adverse event reported associated with MRI units. In this section I introduce the idea that not all MR-related RF thermal injuries are the same. We will discuss several different mechanisms via which a patient may experience a burn during a diagnostic MR examination and highlight not only different causes for these various types of burns but also different steps that one would have to undertake in order to mitigate the risks to our patients (or research volunteers) experiencing such RF related thermal injuries or burns. Multiple clinical examples of various types of RF related focal thermal injuries, or burns, will be presented and analysed. We will discuss how one can differentiate the type of RF thermal injury that transpired by the provided history as well as the shape and distribution of the alleged RF thermal injury.

Time Varying Gradient Safety Considerations: Neurostimulation, Auditory

While transmitted RF energies, which are transmitted at megahertz or radiofrequencies, can be efficiently absorbed by, and converted into, heat by the human body, the frequency with which we typically modulate the time varying imaging gradient magnetic fields used in MRI are typically only a few thousand times per second. Such frequencies are relatively poor at converting to heat. However, the rate at which these imaging gradients are "switched" (i.e., activate when turned on or deactivate when turned off), can efficiently induce direct neuromuscular discharge, or stimulation of nerves/muscles. In other words, an action potential can be caused to discharge and subsequently propagate along a nerve's axon as a result of how we apply the MRI gradients used in the MRI process. The potential effects of stimulating such a neurological neuromuscular discharge - and stimulating whatever tissue or organ that nerve may be attached to - will be discussed. Additionally, rapidly switching these imaging gradients in the presence of the powerful background Bo static magnetic field produces a vibration which, in turn, vibrates the surrounding air at those same very low frequencies. These sounds and noises can be quite loud, can readily exceed published auditory safety thresholds, and have been found to be associated with temporary or even permanent hearing loss.

Cryogen Safety Considerations

The wires in the magnet coil remain in a superconductive state as a result of being bathed in super-cooled liquid helium. The safety of the liquid helium as well as the environment in the event of a quench, or loss of superconductivity, is the focus of this session.

Clinical Application and Decision Making: MR Safety Implant Risk Assessment app; MR safety checklist review, MagnetVision™ app

This part of the course focuses on introducing the attendee to "the Kanal Method", which represents Dr Kanal's own approach to assessing safety for patients with devices, implants, and/or foreign bodies who are asked to undergo MR imaging examinations. Standardization of approaching such an evaluation is a critical component of this process, and Kanal's MR Safety Implant Risk Assessment app will be used to reinforce the process of running his MR safety "checklist" prior to approving – or denying – an implant/device patient access to clinically requested MR imaging studies. Photorealistic MR safety simulation/modelling of patient, implant, scanner hardware, and patient centering and positioning will all collectively interact with simulations of patients and their implanted devices, implants, and foreign bodies to determine whether MR safety thresholds are approached or exceeded for any of the energies used in the MR imaging process.

Open Question and Answer Session

Session asking 'would you scan this patient? Your opportunity to bring your concerns and queries.