Physics of MRI Safety

Magnetic resonance imaging (MRI) is a non-invasive and non-ionizing imaging modality that has an excellent track record for safety in its capacity as a diagnostic imaging device for over 20 years. MRI devices utilize a strong static magnetic field to polarize a sample, radiofrequency pulsed magnetic fields to excite the sample, and rapidly switched magnetic field gradients to spatially and temporally modulate the magnetization in the sample for image encoding. Because of their potential interaction with biological tissue as well as with medical implants or ancillary objects in the room, each of these fields presents a unique potential risk to the patient, staff or family members in the MRI environment that must be mitigated via education and constant vigilance.

Additionally, innovations in MRI design and use can significantly impact safety considerations in and around the suite. MRI is no longer exclusively confined to a diagnostic imaging environment as its use as a treatment planning, interventional or intra-operative imaging device expands. In addition to the safety challenges associated with performing procedures in these unique environments, technological advancements also constantly engage a re-evaluation of MRI safety principles as they apply to monitoring of patients and objects in the MR suite. The use of higher field strengths as well as innovative bore designs which impact the spatial magnetic field gradients, such as wide or short bore magnets, may interact more strongly with implants or objects previously regarded as safe for use in the MRI environment. More powerful gradient systems invite much more rapid or higher resolution imaging acquisitions, which can increase the energy imparted to the patient or implant as well as push the limits of acoustic noise and peripheral nerve stimulation.

The purpose of this continuing education review is to provide an overview for the Medical Physicist of the underlying physics which motivate many of the safety concerns associated with operating in the MRI environment. The primary intent is to provide additional perspective to, and promote a better understanding of, the current safety guidelines and recommendations as well as aid in addressing safety questions and concerns related to developing, operating and working in an MRI suite.

Learning Objectives:
1. Understand the major safety risks associated with MRI from a physics perspective
2. Understand the potential impact MRI technology may have on safety considerations
3. Review current FDA MR safety guidelines