kHz (Gradient) Interactions

Blaine A. Chronik, Ph.D. (bchronik@uwo.ca)

Highlights:

- Interactions between medical devices and technology with the gradient magnetic field of the MR scanner are significant.
- Mechanical vibration, component heating, and electromagnetic interference are all typical interactions caused by the gradient system.
- These interactions are poorly understood and often ignored as compared to RF interactions or interactions with the main magnetic field.

Target Audience: Physicists and engineers working on the development of MR-compatible devices and technology; Clinicians and MR Technologists who want to understand the basic phenomena involved in medical device interactions with MRI systems.

Objectives: Following this talk, attendees should be able to: (1) identify the criteria affecting interactions between gradient magnetic fields and medical devices; (2) identify situations in which these interactions are maximized; (3) identify best-practices for avoiding or minimizing these interactions where possible.

Purpose: Gradient magnetic fields can have significant interactions with medical devices and other technology within the MR scanner, yet these effects are generally poorly understood and rarely discussed as compared to (1) RF interactions, and (2) the forces and torques induced on objects when exposed to the static magnetic field. The purpose of this talk is to increase awareness and understanding of the gradient-induced interactions with medical devices and technology.

Methods: The device-gradient interactions will be introduced using simple models to describe the fundamental physical mechanisms involved. Computer simulations and experimental data will be presented to describe the electromagnetic environment within the scanner bore (in this context). Case studies and examples will be presented to highlight the interactions and focus discussion and questions.

Results: It will be shown that gradient interactions with medical devices can be both significant and difficult to avoid. Mechanical vibration, heating, and interference will be highlighted as significant results of this class of device-system interactions.

Discussion: Gradient interactions are of increased importance when considering the performance of more complex devices (such as pacemakers and robotic systems) in the MR environment. The complex spatial dependence of gradient exposure outside the imaging field-of-view is also a complicating factor. Finally, the lack of practical methods for shielding devices from the low-frequency magnetic fields produced by gradient systems makes managing these effects difficult.

Conclusion: As larger numbers of more complex devices and technology are introduced into the scanner environment, understanding and managing gradient magnetic field interactions will become increasingly important.