Abstract

Breast MRI is a critically important tool in screening for cancer in high-risk women, assessing the extent of known cancers, and in evaluating the integrity of breast implants. It also shows promise for evaluating therapy response. Emerging advanced techniques in breast MRI include abbreviated screening protocols and simultaneous PET/MR. However, there are several technical challenges which limit breast MRI. First, breast MRI generally compromises on image quality to reduce imaging time. Recent developments in deep learning MRI reconstructions may reduce the need for compromise. However, there is no existing research using these reconstruction techniques in a breast setting. Second, abbreviated breast protocols require highly optimized workflows to achieve their stated goal of shortened exam times. Elements of current breast MRI setup are performed manually by MR technologists, are prone to errors, and subject to intra- and inter-operator variability. Automated methods could allow for more rapid and consistent image setup, but such techniques do not currently exist for breast MRI. Third, simultaneous PET/MR of the breast requires administration of both a PET radiotracer and a gadolinium-based contrast agent. Gadolinium is a heavy metal and there is concern that it may attenuate PET annihilation photons and bias quantification of radiotracer uptake.

Three chapters in this work are dedicated to addressing each of the challenges just introduced. First, a deep learning reconstruction was applied to existing and novel breast MR sequences, and the specific benefits to image quality were assessed. Second, an automated method for breast MR imaging setup was developed, and its performance compared to that of human users. Third, the impact of gadolinium-based contrast agents on PET radiotracer uptake measurements was quantified.

MRI is also a sensitive tool for detection of lesions in the abdomen. Specifically, diffusion weighted imaging provides a measure of tissue microstructure which can help distinguish cancerous and normal tissues. Current clinical diffusion weighted imaging allows for a mostly qualitative assessment of diffusion. Quantification through the apparent diffusion coefficient or other diffusion metrics can provide additional insight into tissue microstructure. However, such quantification in the abdomen is particularly difficult due to motion-induced artifacts. While methods to help suppress these artifacts exists, they have been limited to specific scanner hardware configurations. The final chapter in this work describes the implementation of motion-robust diffusion methods on scanners with multiple hardware configurations. The reproducibility of quantitative diffusion metrics across different scanners with different hardware was also assessed.

Overall, the work presented in this thesis made substantial progress in overcoming the challenges of advanced MR imaging techniques in the breast and abdomen.