MR-PET/HIFU/Hybrid Technologies

MR combined with other imaging and intervention methods offers some unique advantages. As an example, ultrasound devices allow controlled energy deposition into a target tissue. This energy deposition is now used clinically to thermally ablate tissue as a replacement for invasive surgical procedures. Combining the ultrasound devices with MRI guidance, monitoring and control provides attractive methods for minimally invasive or completely noninvasive surgery. The first high intensity focused ultrasound (HIFU) devices were integrated in the MRI table and have been tested for the treatment of benign and malignant breast tumors, uterine fibroids, back pain, bone tumors, and liver tumors. Special phased array applicators for brain interventions are also in clinical testing. Similarly, endocavity devices have been developed for prostate treatments. Regulatory approval has been granted in Europe for uterine fibroid, bone, and essential tremor treatments and in the USA for fibroid and bone treatments. These special phased array devices are now being explored for use in MRI targeted drug delivery and hold special promise for use in brain treatments [1].

Significant progress has been made in combining MR with PET to provide simultaneous imaging with these two modalities [2],[3]. The obvious benefits of this approach are as follows: First, the precise registration of both images. Second, the need for only one imaging session, leading to a reduction in imaging time. Third, and perhaps most important, the increased diagnostic value of the combined imaging [4;5],[6].

There are several more advantages that can be derived from this combination, such as the ability to use MRI motion tracking to improve PET imaging in moving organs such as the liver and heart. In addition, such a device, when combined with a HIFU system, offers molecular targeting with the PET and temperature monitoring and control with the MR, potentially providing significant value, for example, for noninvasive cancer ablation.

Other hybrid methods that combine MR with other methods, such as ultrasound imaging [7], may offer enhancements over standard MRI, for example, enhancements that take advantage of the very high imaging speed of ultrasound and that allow for the ability to track blood flow in very small vessels.

In this presentation, the current clinical and experimental results for some of these hybrid methods will be presented and the potential for novel hybrid methods will be discussed.

Bibliography

[1] K. Hynynen, "MRIgHIFU: a tool for image-guided therapeutics," *J Magn Reson. Imaging.*, vol. 34(3), pp. 482-493, Sept.2011.

[2] D. L. Bailey, H. Barthel, T. Beyer, R. Boellaard, B. Guckel, D. Hellwig, H. Herzog, B. J. Pichler, H. H. Quick, O. Sabri, K. Scheffler, H. P. Schlemmer, N. F. Schwenzer, and H. F. Wehrl, "Summary report of the First International Workshop on PET/MR imaging, March 19-23, 2012, Tubingen, Germany," *Mol. Imaging Biol.*, vol. 15(4), pp. 361-371, Aug.2013.

[3] J. Czernin and K. Herrmann, "The potential of PET/MRI imaging in oncology: a comment to a summary report of the First PET/MRI Workshop in Tuebingen in 2012," *Mol. Imaging Biol.*, vol. 15(4), pp. 372-373, Aug.2013.

[4] S. H. Huang, C. Y. Chien, W. C. Lin, F. M. Fang, P. W. Wang, C. C. Lui, Y. C. Huang, B. T. Hung, M. C. Tu, and C. C. Chang, "A comparative study of fused FDG PET/MRI, PET/CT, MRI, and CT imaging for assessing surrounding tissue invasion of advanced buccal squamous cell carcinoma," *Clin. Nucl. Med.*, vol. 36(7), pp. 518-525, July2011.

[5] C. Catana, A. Drzezga, W. D. Heiss, and B. R. Rosen, "PET/MRI for neurologic applications," *J Nucl. Med.*, vol. 53(12), pp. 1916-1925, Dec.2012.

[6] C. Buchbender, T. A. Heusner, T. C. Lauenstein, A. Bockisch, and G. Antoch, "Oncologic PET/MRI, part 2: bone tumors, soft-tissue tumors, melanoma, and lymphoma," *J Nucl. Med.*, vol. 53(8), pp. 1244-1252, Aug.2012.

[7] L. Curiel, R. Chopra, and K. Hynynen, "Progress in multimodality imaging: truly simultaneous ultrasound and magnetic resonance imaging," *IEEE Trans. Med Imaging.*, vol. 26, no. 12, pp. 1740-1746, Dec.2007.