MR-PET, The Potential for Combined Imaging Modalities

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No single imaging modality provides the optimal combination of high spatial and temporal resolution, and high sensitivity for imaging of the abundance and activity of functionally-relevant targets, whether detected at the protein or mRNA level. However, combinations of modalities may approach this ideal, allowing the strengths of more than one technique to be integrated in a single imaging system. In the best-case scenario, this integration occurs without compromise to any of the individual modalities comprising the multimodality imaging system.

The literature contains examples of many combinations of imaging systems (Cherry 2006), but by far the most enduring and commercially successful has been the integration of the nuclear medicine techniques of positron emission tomography (PET) or single photon emission computed tomography (SPECT) with x-ray computed tomography (CT) (Townsend 2008). Combined PET/CT and SPECT/CT scanners have permitted the sensitivity of nuclear medicine radiotracer imaging to be fused with the high spatial resolution of structural imaging with CT. This merger of structural and functional imaging allows the sensitive detection of molecular targets and their precise anatomic localization. This combination has been demonstrated to change patient management in a significant number of cases (Bar-Shalom, Yefremov et al. 2003; Lardinois, Weder et al. 2003) and for this reason PET/CT and SPECT/CT have become widely adopted in clinical diagnostics. They also have become important technologies in preclinical and more basic research in animal models of human disease (Rowland and Cherry 2008).

This presentation will focus on the combination of PET with MR (Cherry, Louie et al. 2008; Pichler, Wehrl et al. 2008). Three obvious questions emerge. 1) Why has PET/MR not received nearly the level of attention and development over the last ten years compared with PET/CT? 2) What can PET/MR offer that PET/CT cannot? 3) Now that prototype PET/MR systems finally are available (Catana, Procissi et al. 2008; Judenhofer, Wehrl et al. 2008; Schlemmer, Pichler et al. 2008), will PET/MR undergo the same dramatic growth that PET/CT did? To answer these questions, we will trace the historical development of PET/MR systems, examine the different approaches and trade-offs inherent in constructing a combined PET/MR instrument and discuss some of the applications for PET/MR that are emerging from the use of the early prototype systems, both in animal and human studies.

References:

Bar-Shalom, R., N. Yefremov, et al. (2003). "Clinical performance of PET/CT in evaluation of cancer: Additional value for diagnostic Imaging and patient management." Journal of Nuclear Medicine **44**(8): 1200-1209.

Catana, C., D. Procissi, et al. (2008). "Simultaneous in vivo positron emission tomography and magnetic resonance imaging." Proceedings of the National Academy of Sciences of the United States of America **105**(10): 3705-3710.

Cherry, S. R. (2006). "Multimodality in vivo imaging systems: Twice the power or double the trouble?" Annual Review of Biomedical Engineering **8**: 35-62.

Cherry, S. R., A. Y. Louie, et al. (2008). "The integration of positron emission tomography with magnetic resonance imaging." Proceedings of the Ieee **96**(3): 416-438.

Judenhofer, M. S., H. F. Wehrl, et al. (2008). "Simultaneous PET-MRI: a new approach for functional and morphological imaging." Nature Medicine **14**(4): 459-465.

Lardinois, D., W. Weder, et al. (2003). "Staging of non-small-cell lung cancer with integrated positron-emission tomography and computed tomography." New England Journal of Medicine **348**(25): 2500-2507.

Pichler, B. J., H. F. Wehrl, et al. (2008). "Positron emission tomography/magnetic resonance imaging: The next generation of multimodality imaging?" Seminars in Nuclear Medicine **38**(3): 199-208.

Rowland, D. J. and S. R. Cherry (2008). "Small-animal preclinical nuclear medicine instrumentation and methodology." Seminars in Nuclear Medicine **38**(3): 209-222.

Schlemmer, H. P. W., B. J. Pichler, et al. (2008). "Simultaneous MR/PET imaging of the human brain: Feasibility study." Radiology **248**(3): 1028-1035.

Townsend, D. W. (2008). "Dual-modality imaging: Combining anatomy and function." Journal of Nuclear Medicine **49**(6): 938-955.