Multimodal Cardiovascular Molecular Imaging
Hybrid MR and PET System

Ciprian Catana, MD, PhD
Athinoula A. Martinos Center for Biomedical Imaging, MGH and HMS

This presentation will review the challenges in combining PET and MRI and the approaches currently investigated to overcome them, describe the current state-of-the-art and present *in vivo* proof-of-principle studies performed, talk about some of the technical and methodological improvements made possible via simultaneous acquisition and discuss potential cardiovascular molecular imaging applications.

PET and MRI are widely used *in vivo* imaging technologies with both clinical and biomedical research applications. MRI's strengths include high resolution and high contrast morphologic imaging of soft tissues, the ability to image physiologic/functional parameters and the measurement of metabolites using MR spectroscopy techniques. PET images the distribution of biologically-targeted radiotracers with high sensitivity, but images generally lack anatomic context and are of lower spatial resolution. Integration of these technologies permits acquisition of spatially and temporally correlated data showing the distribution of PET radiotracers and MRI contrast agents or MR-detectable metabolites, with registration to the underlying anatomy.

It is not a trivial task to combine PET and MRI for simultaneous imaging because there are a number of ways is which the two systems can interfere with each other, causing major artifacts and/or image degradation. In spite of all the challenges, a number of integrated scanners capable of simultaneous acquisition have been developed and successfully tested in small animal studies. More importantly, the recently introduced hybrid whole-body human system capable of simultaneous MR and PET data acquisition has the potential to significantly change the field of cardiovascular molecular imaging.

In addition to the complementary information provided by the two techniques, simultaneous PET and MRI data acquisition opens up the possibility of improving the performance of one instrument by using the information obtained from the other modality. These opportunities range from physical improvements (i.e. increased PET spatial resolution due to positron range reduction in magnetic fields), to methods for improving the quantification of the PET data using the MR information (i.e. MR-assisted motion and partial volume correction, image based estimation of the radiotracer arterial input function), to the possibility of using dual labeled probes for "increasing" the sensitivity of the MR by guiding the data acquisition using the PET information. Furthermore, PET and MR techniques that have been proposed for the same purpose could be cross-validated and potentially improved.

Combined MR-PET is expected to be a more quantitative tool than the two methods alone and it could potentially have a significant impact in all aspects of patient care, ranging from screening, disease assessment and therapy monitoring. To give just a few examples, this new imaging modality could improve the characterization of atherosclerotic plaques by using dual-modal MR-PET probes (e.g. fibrin targeted MR contrast agents labeled with ^{64}Cu), the assessment of myocardial infarction and viability by combining functional and metabolic information (e.g. combined delayed-enhancement MRI with $^{13}NH_3$ and FDG PET), the localization and quantification of angiogenesis targets (e.g. $\alpha v\beta 3$ integrin expression) and the detection of stem cell delivery and migration.