AbstractID: 7936 Title: PET Biomarkers in Radiation Oncology

Recently, the role of PET and PET/CT imaging in oncology has grown dramatically. The following characteristics of PET make it an ideal imaging modality for providing functional information that can be incorporated into radiation treatment planning:

1. Ability to image nanomolar tracer concentrations
2. Excellent tissue penetration
3. Ability to use tracers analogous from the chemical point of view to their naturally-occurring counterparts.

However, while general paradigm of biologically-conformal radiation therapy has been proposed long time ago, we are still far from its implementation in routine clinical radiation treatment planning. Even in the case of such a well established tracer as ^{18}FDG, we are still not certain of how to incorporate the information content of an FDG PET image into radiation treatment plan. While multiple approaches to FDG PET image segmentation designed to allow for tumor delineation have been proposed, all of them are failing to take into account the following factors:

1. Complexity of the tumor boundary (even assuming that the boundary does exist)
2. Highly heterogeneous morphology of the lesion
3. Variability of intratumoral FDG uptake even in homogeneous animal tumor models.

We believe that in order to facilitate further incorporation of PET imaging in radiation treatment planning, the following developments have to take place:

1. Implementation of higher standards of tracer validation. It is not sufficient to show that a tracer designed to image a certain function, like cell division, or an environmental parameter, like hypoxia, is characterized by high tumor uptake. Instead, it is necessary to demonstrate and *in-vivo* that the tracer is in fact binding to the desired target. This can be done by performing carefully designed validation studies utilizing animal tumor models and patient tumor tissue specimens
2. Discrete approaches to PET image segmentation (tumor vs. normal tissue, hypoxia vs. normoxia) have to be dropped in favor of probabilistic approaches. For example, gradual change of FDG uptake from low level in normal tissue to high level in the lesion has to be interpreted as a gradual change in probability of finding a tumor cell, rather than used to randomly assign location of a step-like target boundary.

The overall goal of this presentation is to provide a short overview of the role of PET in radiation therapy treatment planning and to outline some of the research directions that should allow for the development of PET-based biologically-conformal radiation therapy.