AbstractID: 7212 Title: Molecular and Biological Imaging for 3D Radiation Treatment: Paradigm Shift, Pilot Study, and Imaging Science

Conventional 3D radiation treatment planning for tumors uses anatomical information from CT and MR images to identify tumor and surrounding tissues and to determine radiation treatment parameters. A completed treatment plan displays the physical dose distribution with patient anatomy. Tumor biology is not reflected quantitatively, however, tumor radiation response depends not only on anatomy and time-dose schedule, but also on tumor biology. The question is posed: Can tumor biology be imaged and can this information be numerically incorporated to better direct radiation treatment? This presentation addresses this question in three manners: concepts, an example pilot study, and imaging science aspects. AAPM and national initiatives in this area are also reviewed.

Concepts for image-based, biomolecular-directed radiation treatment include anatomical and biological image acquisition, interpretation and manipulation, biophysical models for driving dose levels and dose optimization, and intensity modulated radiation treatment (IMRT) for delivering non-homogeneous dose distributions to biological target volumes. This approach is called Bioanatomic Radiation Treatment. The philosophical shift in image interpretation is from spatial interpretation alone to the interpretation of pixel intensities as well. A pilot study using PET imaging illustrates bioanatomical concepts for brain tumor patients: two characteristics of brain tumor biology, oxygenation and blood flow, are PET imaged by F-18 Misonidazole (hypoxia) and O-15 Water (perfusion). These biological, spatial images of tumor hypoxia and blood flow are combined with anatomical images (CT, MRI) to comprise a bioanatomic representation of the tumor. A key aspect includes IMRT to deliver non-homogeneous, biologically significant doses to segmented portions of the target volume. Quantitative use of molecular and biological images requires an imaging science perspective for image validation and “meaning”. Spatial linearity, resolution, pixel intensity, noise, and other characteristics affect classification and interpretation of image features through manual and automated processes. Validation of image sensitivity and specificity is required to avoid mis-interpretation and mis-application of these unique images.

There is a strong future for applications of novel imaging techniques in radiation treatment. This presentation reviews: concepts for bio-molecular images, an example pilot study, limitations in the use of these images for biologically-directed radiation treatment, and national initiatives related to this developing field. Image-based radiation treatment with bio-molecular images is a dramatic paradigm shift for the practice of radiation treatment, and will (re)unite the radiation oncology and diagnostic radiology/imaging fields in a multi-disciplinary effort that will include biologists and imaging scientists, as well.

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Educational Objectives

1. Understand concepts of biological targeting for radiation treatment.
2. Define types and acquisition methods for molecular and biological images.
3. Understand limitations and potential problems for quantitative use of molecular and biological images: an imaging science perspective.

4. Discuss research areas for molecular and biological images in radiation treatment.
5. Discuss the AAPM Sub-Committee on Molecular Imaging in Clinical Radiation Oncology and other initiatives for research in novel imaging techniques and applications.