Functional imaging in radiotherapy has great promise to guide radiation delivery as well as to monitor response to treatment. Normal tissues as well as tumor tissues may be imaged with functional imaging. This talk will discuss positron emission tomography (PET), single photon emission tomography (SPECT) and Magnetic Resonance Imaging (MRI) in the context of radiation therapy for thoracic and head-and-neck cancers. PET for hypoxia imaging presents an especially appealing way to guide dose painting, wherein doses to hypoxic regions may be increased with the aim of achieving local control. This talk will describe PET hypoxia imaging with F18-FMISO and, importantly, a novel approach that uses kinetic analysis with serial Cu62-ATSM/PTSM imaging to map the distribution of oxygen availability. Radiotherapy planning incorporating PET hypoxia imaging for tumor local control will be discussed, as well as normal tissue dose avoidance using SPECT perfusion imaging to reduce dose to functionally active healthy tissue. Other than radiotherapy guidance, functional imaging may also be used to monitor response to chemoradiotherapy. Functional images taken during the initial treatment period, if predictive of overall treatment response, allows modification of the treatment plan to improve efficacy. Specifically, this talk will discuss F18-FDG PET, dynamic contrast enhanced (DCE) MRI and diffusion MRI to monitor treatment related changes. The intrinsic temporal variability of tumor glucose metabolism versus treatment-induced changes from chemoradiation will be demonstrated. For reliable utilization of FDG PET imaging in early treatment response assessment, intrinsic variability must be less than treatment-induced changes. The leakiness of both tumor and normal tissue blood vessels, as measured with the transfer coefficient obtained from DCE-MRI, may also be used as a measure of early treatment response. Decreased transfer coefficient values in the tumor may be positively interpreted as corresponding to normalization of vasculature. Conversely, increasing transfer coefficient values in normal tissues likely indicate undesirable damage to vasculature. Increase in the tumor apparent diffusion coefficient (diffusion MRI) signals an expansion in the extracellular space, possibly identifying responders. In summary, this talk will discuss functional imaging in the context of guiding radiotherapy planning as well as treatment monitoring.

Learning objectives:

1. Familiarization with the utilization of selected PET, SPECT and MRI techniques in radiotherapy.
2. Functional imaging to guide radiotherapy planning.
3. Treatment response monitoring with functional imaging.