AbstractID: 6991 Title: Principles of Adaptive and Robust Control in Treatment Planning

Local control by radiation therapy relates directly to the dose delivered to the diseased tissue, but can be limited by the dose tolerated by adjacent structures. This axiom has guided clinical practice into a number of technological shifts over the past several decades. Intensity-modulated radiotherapy (IMRT) has emerged as an important means to achieve higher doses and to intensify treatment, while simultaneously decreasing the dose in normal tissues. However, the proximity of critical normal organs to disease and geometric uncertainties arising from organ movement continue to present significant challenges in some anatomical sites.

Advances in image-guided radiation therapy (IGRT) permit more frequent soft-tissue imaging in the course of treatment delivery, creating opportunities to enhance the accuracy and precision of treatment. A framework for considering image-guidance strategies and their implications for treatment planning is required. For example, target localization can improve geometric accuracy in the *on-line* setting; i.e., during treatment delivery. An *off-line* statistical analysis of a patient's images can also enhance precision by supporting the adaptation of margins. Even a complete re-optimization of the plan is possible, in response to systematic anatomical changes accumulated with the progression of treatment. Frequent re-optimization is potentially inefficient and expensive, within the constraints of current technologies, clinical practices, and QA standards. Clearly, there are trade-offs between the level of effort required to an exploit IGRT for *adaptive* re-planning, and the potential benefits of re-planning. The concept of *robust* optimization points to the possibility designing treatment plans that are tolerant to uncertainties in treatment delivery. Robust plans may reduce the need for routine re-planning in response to variations in patient setup, organ movement, or progressive changes leading to organ deformation.

This presentation reviews clinical experience with IGRT, and explores the implications, opportunities and challenges for treatment planning in the era of IGRT. The central principles of using IGRT in IMRT treatment planning with respect to requirements for adaptive re-planning and the design of robust IMRT treatments.

Educational objectives:

1. To review illustrate clinical applications of IGRT.
2. To describe how the adoption of IGRT can influence external beam treatment planning.
3. To outline how IGRT information is used for re-planning of IMRT treatments, and in the design of plans that are tolerant to uncertainties in treatment delivery.