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State-of-the-Art External Beam Radiation Therapy: Challenges and Opportunities

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Intensity-modulated radiation therapy (IMRT) and image-guided radiation therapy (IGRT) allow delivery of highly conformal non-convex dose distributions. However, these treatment modalities require precise knowledge of multimodality imaging, internal organ motion, tumor control probabilities, normal tissue complication probabilities, three-dimensional dose calculation and optimization, dynamic beam delivery of non-uniform beam intensities, and most importantly the knowledge of uncertainties in the radiation therapy planning and delivery process. These uncertainties arise from a variety of sources throughout the whole process that consists of three distinct steps: imaging, planning, and delivery. In the imaging step, 3D patient information is obtained for treatment planning. Any problem in the acquisition, transfer, conversion, registration, or use of imaging data can lead to increased geometrical uncertainties. Dose calculation algorithms have inherent errors, because they are based on approximate solutions to a complex physical situation. The assumptions of a RTP system in modeling a treatment machine significantly impact dose calculation accuracy. The accuracy of the beam geometry depends on the tolerance of each machine parameter and the magnitude of setup errors. Therefore, one must clearly identify and account for all sources of error in imaging, treatment planning, and delivery process to understand the uncertainty in dose delivered to a patient with IMRT/IGRT. It is necessary to properly account for these uncertainties in radiation therapy to improve the accuracy of the dose delivered to patients. This presentation will provide the framework and guidance to safely implement these technologies in the clinic.