Purpose: This study analyzes the results of image-guided prostate photodynamic therapy (PDT) that integrates PDT dosimetry, light source optimization, computerized light power adjustment, and volumetric real-time light fluence calculation to deliver uniform photodynamic dose to the target volume (prostate) and spares the critical structures (rectum and bladder).

Methods and Materials: All procedures are under the image guidance of transrectal ultrasound. The PDT dosimetry includes multi-channel real-time in-vivo light dosimetry, absorption and fluorescence spectroscopy for 3D optical properties, drug concentrations, and tissue oxygenation. Drug concentration is also determined using fluorescence from a single optical fiber. These measurements are made before and after motexafin lutetium (MLu)-mediated photodynamic therapy (PDT) using a computerized step motor. The light fluence rate distributions are also measured along the catheters during PDT and compared to the 3D volumetric light fluence calculations. Real-time light fluence calculation was performed on the 3D target volumes using ultrasound image guidance. An optimization algorithm determines the light source strength, lengths, location, and retraction for cylindrical diffusing fibers (CDF) based on the 3D heterogeneous optical properties. The resulting light source power is feedback into a 12-channel beamsplitter that is connected to a motorized attenuator system to control the light source intensity interactively during PDT.

Results: Preliminary data have shown widespread heterogeneities of optical properties and photosensitizing drug distribution. As a result of these heterogeneities, methods to quantifying the three-dimensional (3D) distributions of these quantities in individual prostate are essential for the successful application of PDT. Comparison of light fluence rate between real-time measurements and calculation is performed in heterogeneous medium and the standard deviations are within 30% with a simplified model and better than 11% for an improved model.

Conclusions: We have shown the rational and potential for an integrated system that is capable of obtaining critical parameters (light, drug, and oxygenation) and using the PDT dosimetry result as feedback to optimize treatment delivery. We concluded that a real-time dosimetry and feedback system for monitoring PDT dose during treatment is both achievable and required for clinical interstitial PDT applications.

Educational Objectives:

1. To explain the basic principle of PDT dosimetry.
2. To review explicit PDT dosimetry techniques to characterize tissue optical properties, drug concentration, tissue oxygen concentration, and PDT efficacy.
3. To discuss the rational and requirement for a feedback system incorporating PDT dosimetry, PDT dose optimization, and computerized light delivery.
4. Summarize the clinical results of Prostate PDT.