Energy-Based Dosimetry of Low-Energy, Photon-Emitting Brachytherapy Sources

Martha Malin

Under the supervision of Larry A. DeWerd

At the University of Wisconsin-Madison

May 15, 2015

Model-based dose calculation algorithms (MBDCAs) for low-energy, photon-emitting brachytherapy sources have advanced to the point where the algorithms may be used in clinical practice. Before these algorithms can be used, a methodology must be established to verify the accuracy of the source models used by the algorithms. Additionally, the source strength metric for these algorithms must be established.

This work explored the feasibility of verifying the source models used by MBDCAs by measuring the differential photon fluence emitted from the encapsulation of the source. The measured fluence could be compared to that modeled by the algorithm to validate the source model. This work examined how the differential photon fluence varied with position and angle of emission from the source, and the resolution that these measurements would require for dose computations to be accurate to within 1.5%. Both the spatial and angular resolution requirements were determined.

The techniques used to determine the resolution required for measurements of the differential photon fluence were applied to determine why dose-rate constants determined using a spectroscopic technique disagreed with those computed using Monte Carlo techniques. The discrepancy between the two techniques had been previously published, but the cause of the discrepancy was not known. This work determined the impact that some of the assumptions used by the spectroscopic technique had on the accuracy of the calculation. The assumption of isotropic emission was found to cause the largest discrepancy in the spectroscopic dose-rate constant.

Finally, this work improved the instrumentation used to measure the rate at which energy leaves the encapsulation of a brachytherapy source. This quantity is called emitted power (EP), and is presented as a possible source strength metric for MBDCAs. A calorimeter that measured EP was designed and built. The theoretical framework that the calorimeter relied upon to measure EP was established. Four clinically relevant ^{125}I brachytherapy sources were measured with the instrument. The accuracy of the measured EP was compared to an air-kerma strength-derived EP to test the accuracy of the instrument. The instrument was accurate to within 10%, with three out of the four source measurements accurate to within 4%.