Limitations of current dosimetry for intracavitary accelerated partial breast irradiation with high dose rate iridium-192 and electronic brachytherapy sources

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Intracavitary accelerated partial breast irradiation (APBI) is a method of treating early stage breast cancer using a high dose rate (HDR) brachytherapy source positioned within the lumpectomy cavity. An expandable applicator stretches the surrounding tissue into a roughly spherical or elliptical shape and the dose is prescribed to 1 cm beyond the edge of the cavity. Currently, dosimetry for these treatments is most often performed using the American Association of Physicists in Medicine Task Group No. 43 (TG-43) formalism.

The TG-43 dose-rate equation determines the dose delivered to a homogeneous water medium by scaling the measured source strength with standardized parameters that describe the radial and angular features of the dose distribution. Since TG-43 parameters for each source model are measured or calculated in a homogeneous water medium, the dosimetric effects of the patient's dimensions and composition are not accounted for. Therefore, the accuracy of TG-43 calculations for intracavitary APBI is limited by the presence of inhomogeneities in and around the target volume. Specifically, the breast is smaller than the phantoms used to determine TG-43 parameters and is surrounded by air, ribs, and lung tissue. Also, the composition of the breast tissue itself can affect the dose distribution.

This dissertation is focused on investigating the limitations of TG-43 dosimetry for intracavitary APBI for two HDR brachytherapy sources: the VariSource ^{TM} VS2000 ^{192} Ir source and the Axxent® miniature x-ray source. The dose for various conditions was determined using thermoluminescent dosimeters (TLDs) and Monte Carlo (MC) calculations. Accurate measurements and calculations were achieved through the implementation of new measurement and simulation techniques and a novel breast phantom was developed to enable anthropomorphic phantom measurements.

Measured and calculated doses for phantom and patient geometries were compared with TG-43 calculated doses to illustrate the limitations of TG-43 dosimetry for intracavitary APBI. TG-43 dose calculations overestimate the dose for regions approaching the lung and breast surface and underestimate the dose for regions in and beyond less-attenuating media such as lung tissue, and for lower energies, breast tissue as well.