Dosimetry of the Leksell gamma knife

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No accepted official protocol exists for the dosimetry of the Leksell Gamma Knife® (GK) stereotactic radiosurgery device. Establishment of a dosimetry protocol has been complicated by the unique partial-hemisphere arrangement of 201 separate ^{60}Co beams simultaneously focused on the treatment volume and by the rigid geometry of the GK unit itself. This paper proposes an air kerma based dosimetry protocol using an in-air or in-acrylic phantom measurement to determine the dose rate of fields collimated by the 18 mm helmet of a GK unit. A small-volume ionization chamber was used to make measurements at the physical isocenter of three GK units. The dose rate to water was determined using a modified version of the AAPM Task Group 21 protocol designed for use with ^{60}Co-based teletherapy machines. This experimentally determined dose rate was compared to the treatment planning system (TPS) dose rate that is determined by the clinical medical physicist at the time of machine commissioning. The TPS dose rate is defined as dose rate to water at a depth of 8 cm. The dose rate to water for the 18 mm helmet determined using the air kerma based calculations presented here is consistently between 1.5% and 2.9% higher than the TPS dose rate. These air kerma based measurements allow GK dosimetry to be performed with an established dosimetry protocol and without complications arising from the use of and possible variations in solid phantom material. Measurements were made with the same chamber in a spherical acrylic phantom for comparison. This methodology will allow future development of calibration methods appropriate for the smaller fields of GK units to be compared to a well established standard. Multiple three-dimensional dosimetry methods were also used to capture the dose distribution of the entire field of the GK. These methods included radiosensitive gel, a novel three-dimensional radiochromic film phantom, and Monte Carlo modeling. These methods were also compared to the dose distribution calculated by the TPS used with the GK unit. Volume analysis was performed that compared the volume irradiated to relative dose levels for the GK fields using data from dose volume histograms computed for these methods.